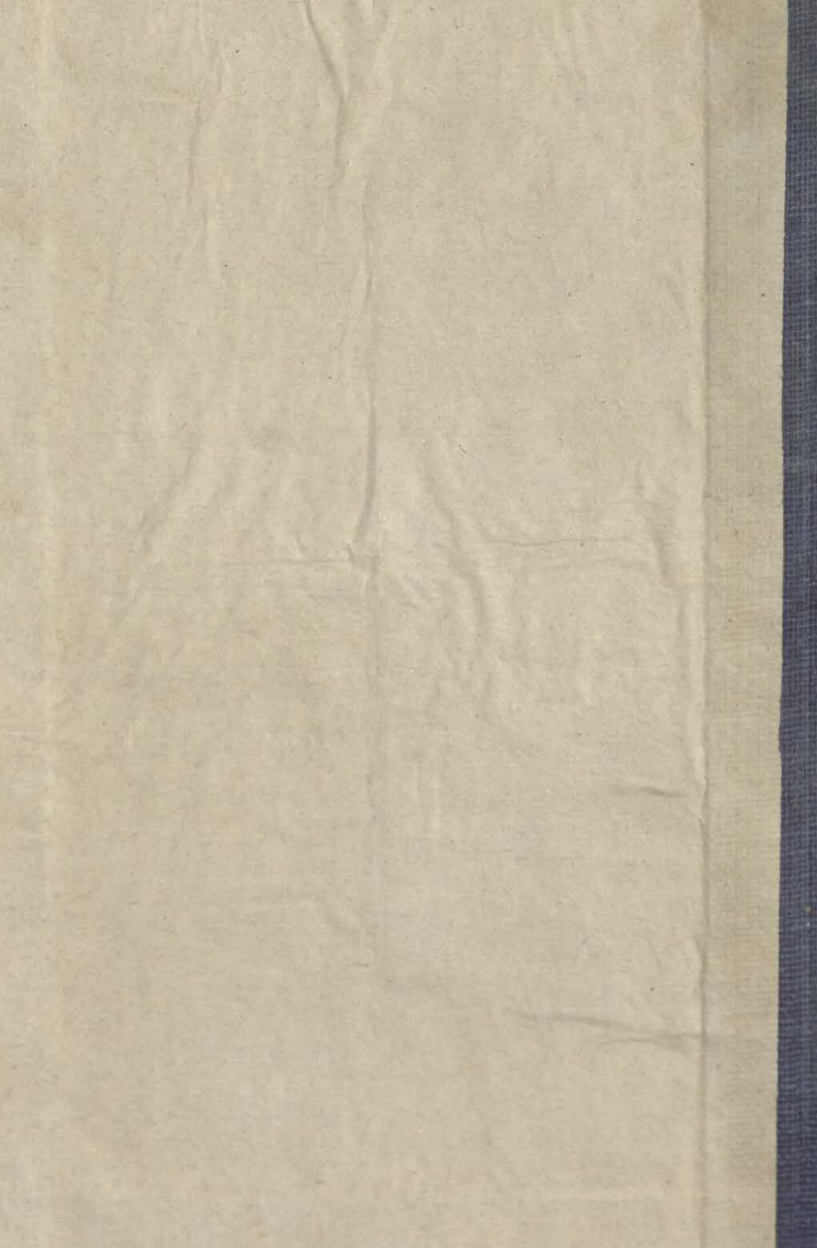
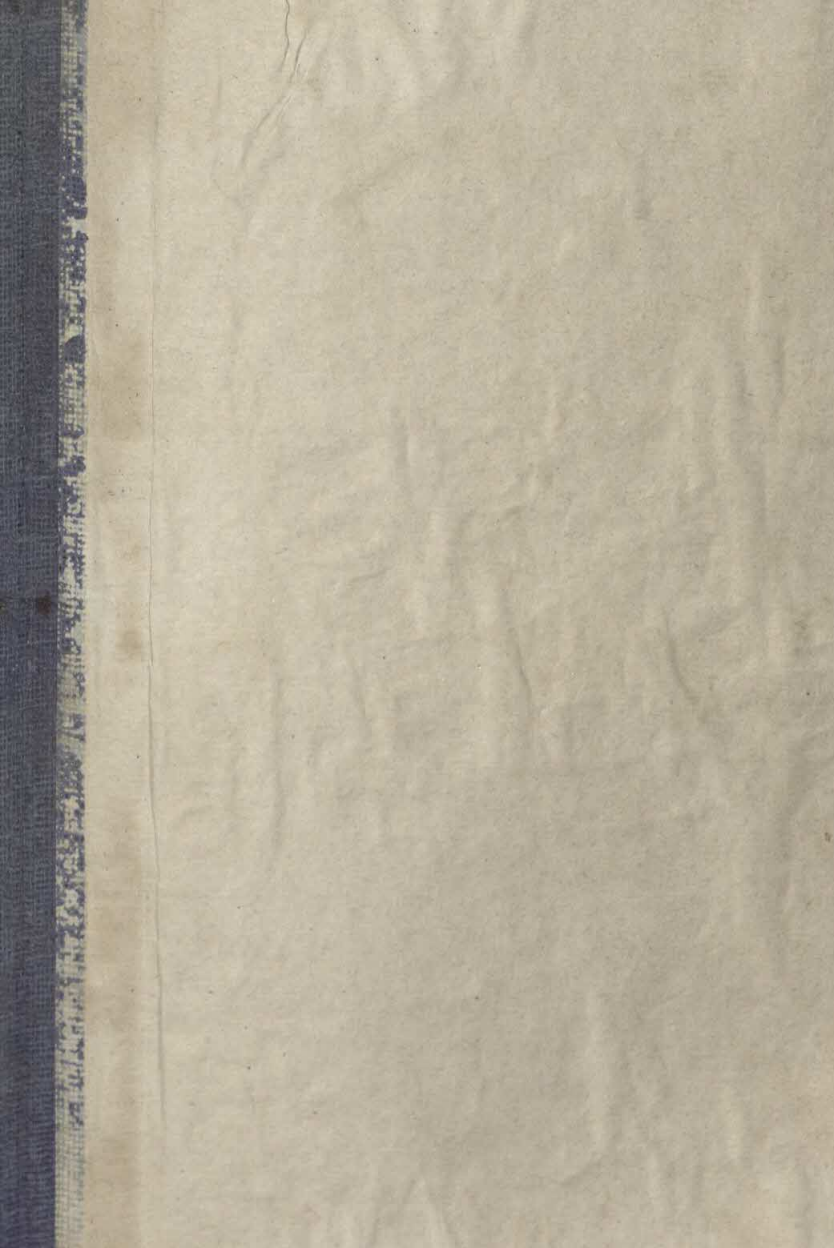


**A NEW APPROACH TO
PRACTICAL CHEMISTRY**

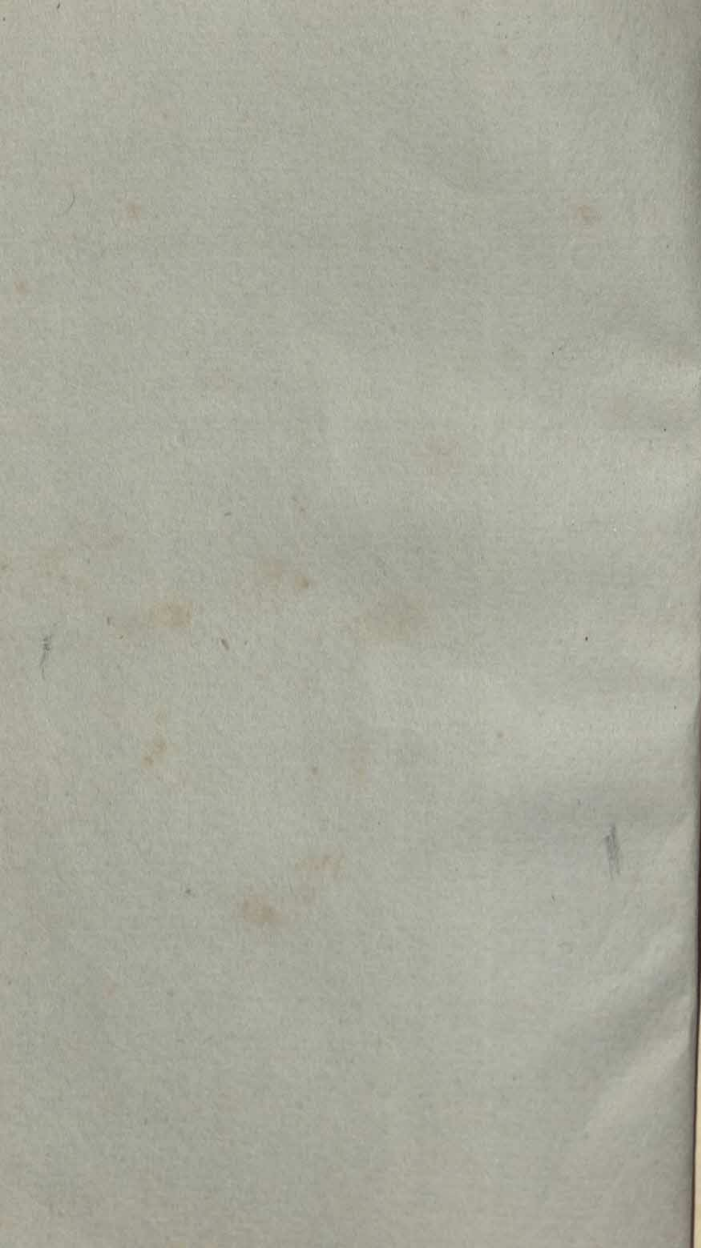
R. BHEEMAN







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**A NEW APPROACH
TO
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(EXPERIMENTS & ACTIVITIES)**

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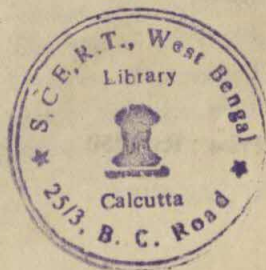
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A NEW APPROACH
to
PRACTICAL CHEMISTRY
(EXPERIMENTS AND ACTIVITIES)

*(For IX & X classes
under 10+2+3 Pattern of Education)*

Dr. B. BHUSHAN

M.Sc., Ph.D.



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PREFACE

This book has been written strictly according to the syllabus prescribed by the Central Board of Secondary Education for 9th and 10th classes under the new 10+2 system of school education.

In every chapter principle of the experiment has been tried to explain. Most of the tests and methods of determinations have been recommended after performing the experiments in the laboratory. It is believed that the material contained in the book is sufficiently comprehensive and enables the students to do experiments successfully and confidently.

This is the first edition of the book and as such it may have a number of drawbacks. Suggestions for the improvement of the book will be gratefully received. The author expresses his grateful thanks to Dr. B. S. Garg, Lecturer, Department of Chemistry, University of Delhi, for going through whole of the manuscript and his valuable suggestions.

—THE AUTHOR

Syllabus

(Class IX and X under the 10+2 Pattern)

SYLLABUS OF PRACTICAL CHEMISTRY OF CENTRAL BOARD OF SECONDARY EDUCATION, NEW DELHI

(i) Verification of Boyle's Law.

(ii) Preparation and study of the simple properties of the gases—chlorine, hydrogen chloride, ammonia, hydrogen sulphide, nitrogen, oxygen and sulphur dioxide (only those methods of preparation to be used as mentioned in the Text-Book).

(iii) (a) Identification of chloride, bromide, iodide, nitrate, phosphate and sulphide as individual radical.

(b) Identification of Pb, As, Sn and Cu by precipitating them as sulphides.

(c) Detection of ferrous (Fe^{++}) and ferric (Fe^{+++}) ions.

Note. Two separate salts may be given to identify each radical of (a), (b) and (c).

(iv) Determination of the solubility of some simple salts in water at room temperature.

(v) Effect of different concentrations of hydrochloric acid on its action on marble and zinc and comparison of the relative rates of reaction.

(vi) Testing of milk, oils and fats (qualitative).

(vii) Determination of the calorific value of some volatile combustible substances.

(viii) Testing for the following in some organic compound :

(a) Saturation and unsaturation ($\text{C}=\text{C}$)

(b) Functional groups : $-\text{CHO}$, $-\text{COOH}$, $-\text{CH}_2\text{OH}$, $-\text{NH}_2$

(c) Detection of the following elements in some organic compounds ; Cl, Br, I, N and S.

(ix) Preparation of Soap.

(x) To assemble the models of some simple organic molecules, e.g., methane, ethane, chloroform and ethyl alcohol.

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7. General Principles of the Theory of the Plasma
8. General Principles of the Theory of the Solid
9. General Principles of the Theory of the Liquid
10. General Principles of the Theory of the Gas
11. General Principles of the Theory of the Plasma

APPENDIX

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10. General Principles of the Theory of the Gas
11. General Principles of the Theory of the Plasma

CHAPTER 1

SOME PRELIMINARY EXPERIMENTS

In the chemical laboratory, students are often required to fit up apparatus, say for the preparation of a gas. So a knowledge of techniques of certain preliminary operations like cutting and bending of glass tube, drawing jets, boring holes in cork, fitting glass tube into the bored corks, etc., is essential.

1. To cut a glass tube :

It involves three steps :

(i) *Making a scratch.* Hold the tube in your left hand firmly and place it on the table such that the thumb points out the place to be cut. Make with the sharp edge of a triangular file, a *fine, single and straight scratch* by drawing it inward with a little pressure (Fig. 1). *The file is not to be moved backward and forward again and again.*

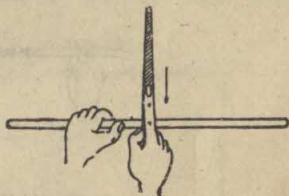


Fig. 1. Making a file scratch.

(ii) *Breaking at the scratch.* After making the scratch, hold the tube in both hands in such a way that the two thumbs are



Fig. 2. Breaking the tube.



Fig. 3. Rounding off the edges.

on either side of the scratch, but are opposite to the scratch. Apply pressure in the outward direction with the thumbs to break it (Fig. 2). Put a fresh scratch at the same scratch if the tube offers resistance.

(iii) *Rounding the edges.* Keep the sharp, freshly cut edge rotating in the flame for a while so that it is rounded off. *Do not heat the tube for a long time otherwise it will be closed.*

2. To bend a glass tube :

Hold the portion of the tube to be bent horizontally in the blue flame of the burner. Keep the tube rotating till it softens.



Fig. 4. Heating of the glass tube.

Now release one of its ends to allow it to bend with its own weight and later take it out of the flame and bend it gently to the desired angle.

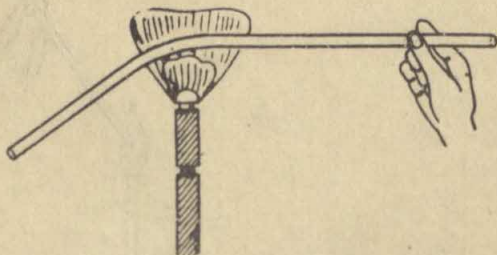


Fig. 5. Bending of glass tube under its own weight.

Now place the bent tube while hot on an asbestos sheet and press it such that whole of it touches the sheet. Allow it to undergo slow cooling. Clean the tube before use.

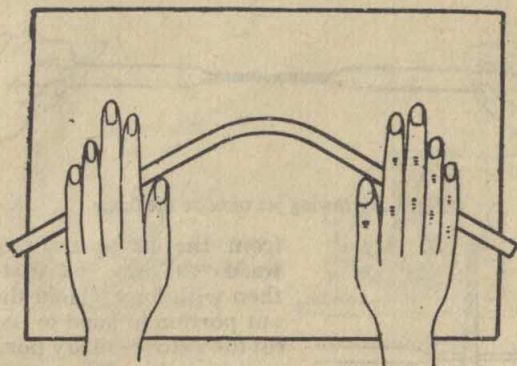


Fig. 6. Setting the bend in the same plane.

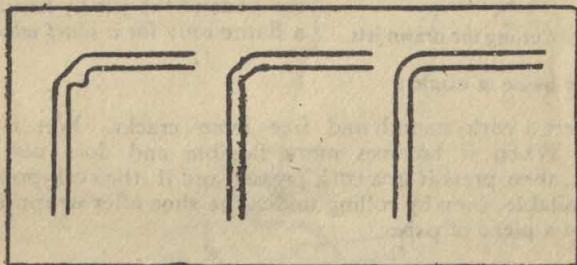


Fig. 7. Spoiled bend and right bend.

Precautions. (i) Keep the tube rotating in the flame.

(ii) Start bending only when it is soft and do not apply force. Otherwise the tube might break or the bend will be flat.

(iii) Never try to change the angle of a bent tube by reheating.

3. To draw a jet :

Select a delivery tube of suitable diameter and cut about six inches of it and hold its edges in the flame to round them. Heat the middle of it in a broad flame by rotatory motion and continue heating till it softens. Withdraw the tube

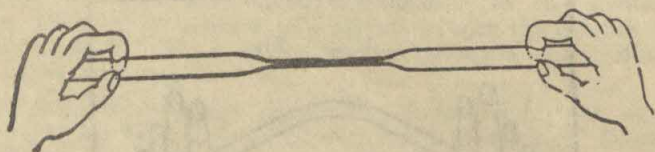


Fig. 8. Drawing jet outside the flame.

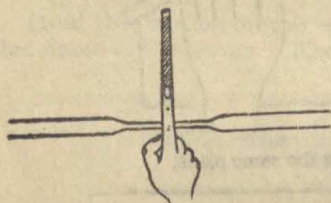


Fig. 9. Cutting the drawn jets.

from the flame and pull it outward to draw jet first slowly, then with force. Hold the drawn out portion in hand to cool and cut the extra capillary portion with a triangular file; consequently two jets will be obtained. Round the ends of the jets by heating in a flame only for a *short while*.

4. To bore a cork :

Select a cork, smooth and free from cracks. Wet it with water. When it becomes more flexible and does not crack readily, then press it in a cork presser and if the cork-presser is not available, then by rolling under the shoe after wrapping the cork in a piece of paper.

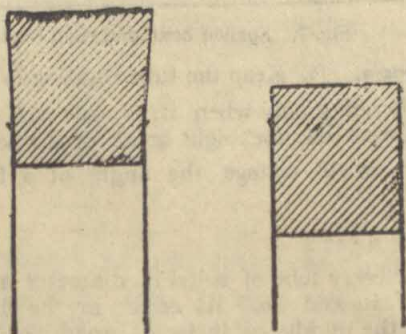


Fig. 10. Proper choice of cork

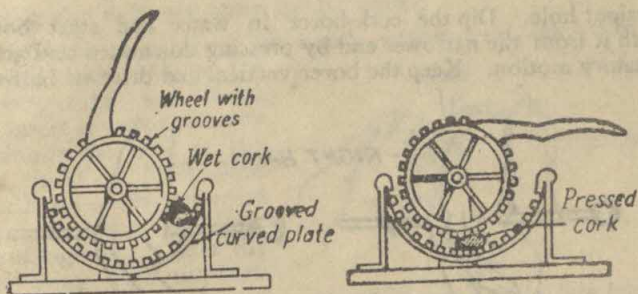


Fig. 11. Pressing the cork in cork-presser.



Fig. 12. Pressing the cork with shoe.

Select a borer slightly smaller in diameter than that of the tube to be fitted in the cork. Hold the cork in your left hand.

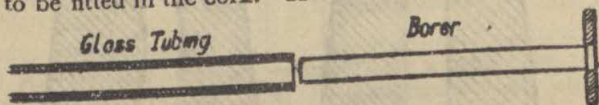


Fig. 13. Selection of suitable borer.

Place it on the table with its narrow end upward. Mark the position of the borer on both the sides of the cork to ensure

straight hole. Dip the cork-borer in water and start boring with it from the narrower end by pressing downward and giving rotatory motion. Keep the borer vertical and drive it half-way

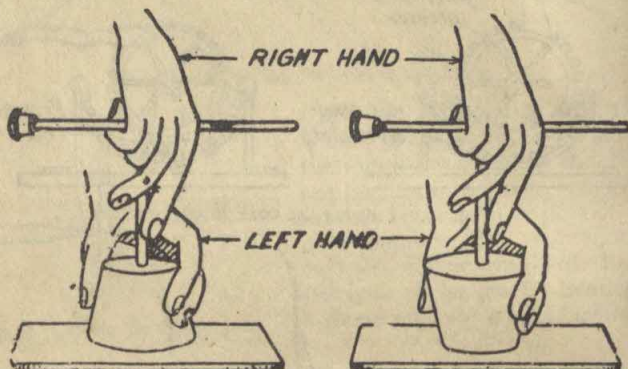


Fig. 14. Boring of cork.

from the narrow end. Pull the borer out by a twist and remove the piece of cork from it by means of a needle. Turn the cork upside down and repeat the boring operation from broad end exactly in the same manner such that the holes from both ends meet straight.



Correct bore.

Wrong bore.

Fig. 15.

Remove the cork stickings by inserting the needle. *A round file should never be used for cleaning the bore.*

Fitting the delivery tube in the cork :

Hold the cork in your left hand, wrapped on side with a piece of cloth. Moisten the delivery tube with water and insert it with a rotatory motion in the hole of the cork, holding it in your right hand partly wrapped in another piece of cloth. It is dangerous to hold the tube away from the cork as it may break and cause injury to the hand.

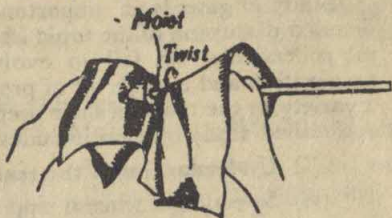


Fig. 16. Inserting a glass tube into a bored cork.

How to make the apparatus air-tight :

An apparatus can be made air-tight by applying either a paste of plaster of paris or wax on the leaking joints. *Never apply wax for this purpose, when apparatus is to be heated during the experiment.*

How to record experiments in the note-book :

Left hand page

Diagram in pencil
Chemical equation
Observations and Calculations

Right hand page

Date.....
Experiment :
Apparatus :
Procedure :
Precautions :

- (i) Always start a new experiment from a fresh page.
- (ii) Chemical changes must be elaborated with chemical equations wherever possible.
- (iii) Keep the index in the beginning of the note-book up to date.
- (iv) Write the procedure methodically and precisely.
- (v) Never cook the data and work honestly.

CHAPTER 2

GASES

Study of gases is an important course at school stage. A detailed discussion of the topic is, therefore, imperative. Viewing collectively, we fail to evolve a single method for their preparation and a single set of properties for them. They present a variety in the mode of their preparations and their behaviour. A detailed study of a gas includes :

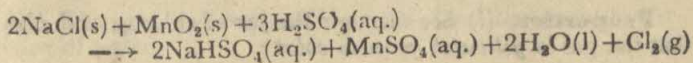
- (i) Understanding of the reaction involved.
- (ii) Selection of general apparatus.
- (iii) Collection of suitable chemicals for preparation and the study of properties.
- (iv) Fitting of apparatus.
- (v) Precautions to be observed.
- (vi) Study of properties.

Record of properties of Gases. The properties of the gas are recorded on the right-hand page of the note-book in a tabular form as given in the specimen record below. The left side is to be utilized for labelled diagram, chemical equations, etc.

<i>Experiment</i>	<i>Observation</i>	<i>Inference</i>
1. Observe the colour of the gas in the jar.	Colourless	A colourless gas
2. Smell the gas from a distance.	No smell	An odourless gas
3.
4.

1. CHLORINE GAS (Cl_2)

Chlorine gas is prepared in the laboratory by heating a mixture of manganese dioxide, concentrated sulphuric acid and sodium chloride.



Requirements. A round-bottom flask, cork with two holes, thistle funnel, delivery tube bent twice at right angles, gas jars with discs, tripod stand, wire gauze, iron stand, wooden blocks, concentrated sulphuric acid, manganese dioxide, sodium chloride, litmus solution, petals of a flower, candle, deflagrating spoon, yellow phosphorus, powdered antimony, KI solution, starch, etc.

Procedure. Fit up the apparatus as shown in Fig. 17. Grind approximately equal amounts of sodium chloride and manganese dioxide together and place it in the round-bottom flask. Pour concentrated sulphuric acid through the thistle funnel enough to cover the lower end of the thistle funnel and the solid mixture.

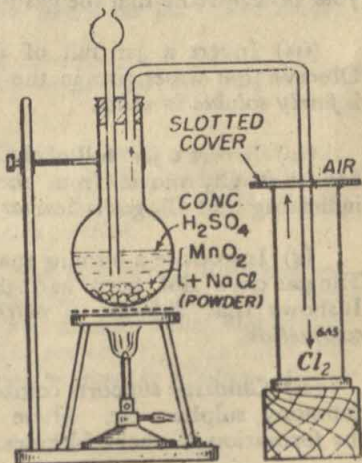


Fig. 17. Lab. preparation of chlorine gas.

Heat the flask gently until a greenish yellow gas is evolved. Collect a few jars of gas by upward displacement of air and test its few properties.

Precautions. (i) Apparatus should be air-tight.

(ii) The gas should be prepared in a fumes cup-board since it is poisonous.

(iii) The lower end of the thistle funnel should always be dipped in solution.

(iv) Do not inhale the gas.

Properties. (i) See through the jar of chlorine and observe that the gas is *yellowish green in color*.

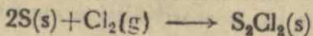
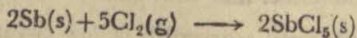
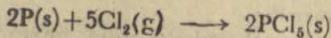
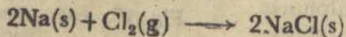
(ii) Open the jar and wave the gas with your hand towards your nose. Note that the gas has a *peculiar irritating smell*.

(iii) Invert a jar full of the gas in a trough of water. Observe that water rises in the cylinder showing that the gas is *fairly soluble in water*.

(iv) Invert a jar full of the gas over another jar. You will find that Cl_2 moves from the upper jar to the lower one indicating that Cl_2 gas is *heavier than air*.

(v) Introduce a burning match-stick in a jar of chlorine. The gas does not burn and the match-stick is extinguished. It shows that chlorine is *neither combustible nor a supporter of combustion*.

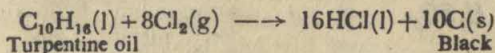
(vi) Chlorine supports combustion of sodium, phosphorus, antimony, sulphur, etc. These elements burn in chlorine with the formation of their chlorides.



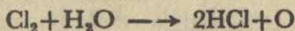
(vii) Take a lighted candle in the gas jar. It will burn with a dull red flame forming a black cloud of carbon.

(viii) Soak a filter paper in turpentine oil, warm it and plunge it in the jar of chlorine. The filter paper catches fire

giving a black cloud of carbon and white fumes of hydrochloric acid.



(ix) The gas is a *strong oxidising and bleaching agent* in the presence of water.

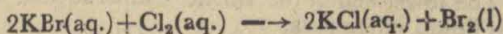
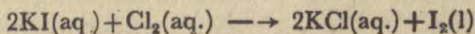


(a) Put moist petal of a flower in the gas jar. The colour of the petal is bleached.

(b) Put some indigo solution in the gas jar and shake. It turns colourless.

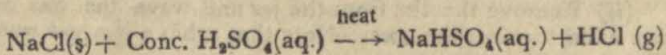
(x) Introduce a moist blue litmus paper in a jar of Cl_2 gas. Observe that it first changes red and then white. Change of blue litmus to red shows *its acidic nature* and turning finally to white illustrates *its bleaching action*.

(xi) Take the solutions of KI and KBr in two different test tubes. Add to each a little of chlorine water and CS_2 . Note that CS_2 forms a distinct layer and assumes violet and orange colours in the tubes of KI and KBr respectively. It infers that *chlorine displaces iodine and bromine from the solutions of their compounds*.



2. HYDROGEN CHLORIDE GAS (HCl)

Hydrogen chloride gas in the laboratory is prepared by heating sodium chloride (common salt) with concentrated sulphuric acid. The reaction involved is



Requirements. A round-bottom flask, cork with two holes, thistle funnel, delivery tube bent twice at right angles,

gas jars with covers, tripod stand, wire gauze, iron stand, sodium chloride, concentrated sulphuric acid, ammonium hydroxide, silver nitrate, zinc pieces, manganese dioxide.

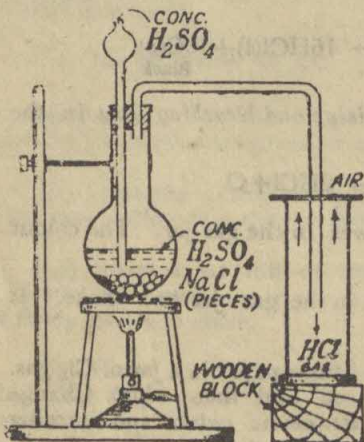


Fig. 18. Lab. preparation of HCl gas.

Procedure. Arrange the apparatus as shown in Fig. 18. Put some common salt in the round-bottom flask and replace the cork. See that the lower end of the thistle funnel just approaches the bottom of the flask. Clamp the flask gently and pour concentrated sulphuric acid through the thistle funnel little at a time. Warm the mixture and collect gas in few jars by upward displacement of air. Study its few properties.

Precautions. (i) The apparatus should be air-tight.

(ii) The jar must be free from moisture.

(iii) The lower end of the thistle funnel should always be dipped in liquid in the flask.

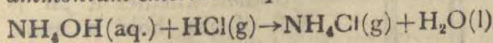
(iv) Do not inhale the gas.

Properties. (i) Look at the gas in the jar and note that it is colourless.

(ii) Remove the disc from the jar and wave the gas with your hand towards the nose. Note that it has a *pungent smell*.

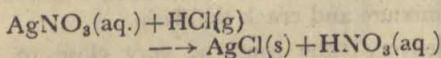
(iii) Put a very little water in one of the jars full of gas and immediately replace its lid. On shaking, the gas will dissolve in water and leave a vacuum. Invert it in a trough of water and remove the lid. The water will rush into the jar and will nearly fill it. This shows that *HCl gas is very much soluble in water.*

(iv) Put a little ammonium hydroxide solution in a gas jar and invert a jar filled with gas over it. *Dense white fumes of ammonium chloride are produced.*



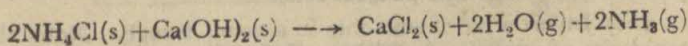
(v) Put a blue litmus paper or solution in a jar of the gas. Note that it changes to red *showing acidic nature of the gas.*

(vi) Put silver nitrate solution in a jar full of gas, a white precipitate will be obtained.



3. AMMONIA GAS (NH_3)

Ammonia gas can be prepared in the laboratory by heating ammonium chloride with slaked lime. The action involved is



Since it is lighter than air, it is collected by downward displacement of air method. But like other gases, it cannot be collected over water, as it is highly soluble in water.

Requirements. A round-bottom flask, cork with single bore, delivery tube bent at an angle of 60° , wire gauze, iron stand, gas jars with lids, ammonium chloride, slaked lime, litmus paper, turmeric paper, phenolphthalein, ferric chloride, zinc sulphate, copper sulphate, etc.

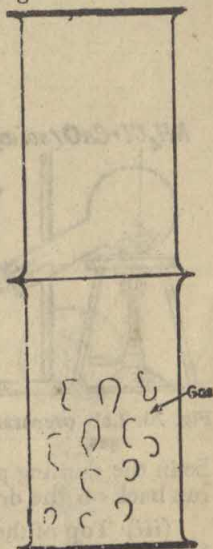


Fig 19. Effect of HCl gas upon Ammonia.

Procedure. Powder separately some ammonium chloride and slaked lime in a mortar. Mix nearly equal weights of the two substances and introduce the mixture in a round bottom flask. Arrange the apparatus as shown in Fig. 20.

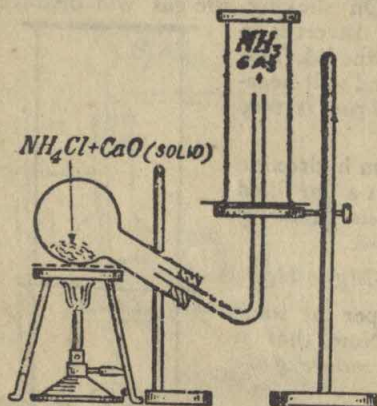


Fig. 20. Lab. preparation of ammonia gas.

Heat the flask gently and collect the gas in a few jars by downward displacement of air method. To know whether a jar is full of gas, hold a moist red litmus paper near the mouth of the jar. If it turns blue, the jar is full of gas.

Precautions. (i) Use perfectly dry apparatus.

(ii) The flask should be in the slanting position, otherwise the condensed water may run back on the dry mixture and crack the flask.

(iii) Top of the delivery tube must be very close to the bottom of the jar.

(iv) Keep the jar inverted on the table.

Properties. (i) Observe the gas in the jar. *It is colourless.*

(ii) Ascertain the odour of the gas and note that NH_3 possesses a *characteristic pungent smell*.

(iii) Invert a jar of ammonia in a water trough. Note the rapid rise of water inside the jar. *Infer that the gas is highly soluble in water.* Its high solubility in water can also be shown by another beautiful experiment, called *Fountain experiment*.

Take a round-bottom flask. Fit it with an air-tight cork having a hole in its centre. Fit a long glass tube, drawn in a jet at one end, in the cork with jet inside the flask. Fill the flask with the gas and fit the cork in its mouth. Close the open end of the tube with your finger. Invert the flask and remove the finger under water, in which some phenolphthalein is dis-

solved in a beaker. Water at once rushes up in the flask and appears at the jet in the form of a pink fountain.

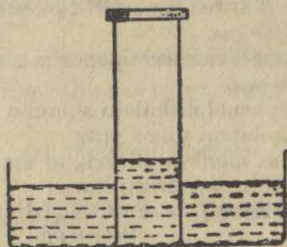


Fig. 20(a) Testing the solubility of gas.

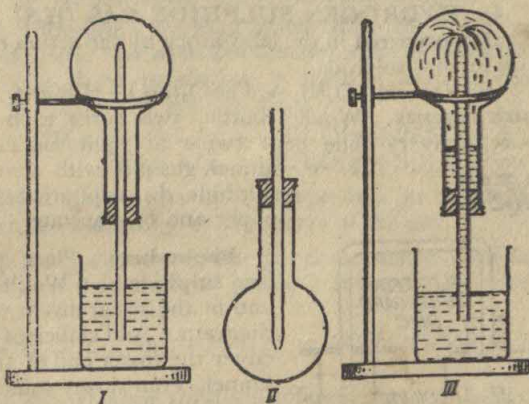


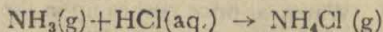
Fig. 20(b) Fountain Experiment

(iv) The mode of collection of the gas, i.e., downward displacement of air method indicates its lighter nature.

(v) Introduce a burning splinter in a jar of ammonia and observe that the gas neither burns nor helps in burning. The gas is combustible if burnt at the jet end in the presence of excess of oxygen.

$$4\text{NH}_3(\text{g}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{N}_2(\text{g}) + 6\text{H}_2\text{O}(\text{g})$$

(vi) Bring a glass rod dipped in concentrated HCl near the mouth of a jar of NH_3 . Dense white fumes will evolve.

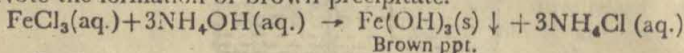


(vii) Pour red and blue litmus solution in separate jars of ammonia. Observe that red litmus is *turned blue indicating the alkaline character of the gas.*

(viii) Introduce a wet turmeric paper in a jar of ammonia. Note that it turns brown.

(ix) Pour some phenolphthalein solution in a jar of ammonia. Note that the solution turns pink.

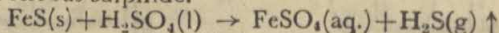
(x) Add aqueous solution of NH_3 to the solution of FeCl_3 . Note the formation of brown precipitate.



Perform the experiment with $\text{Al}_2(\text{SO}_4)_3$, ZnSO_4 , MnSO_4 and observe the action.

4. HYDROGEN SULPHIDE GAS (H_2S)

H_2S gas is prepared in the laboratory by the action of dilute H_2SO_4 on ferrous sulphide.



Requirements. Woulf's bottle, two corks each with a single bore, delivery tube bent twice at right angles, thistle funnel, gas jars with covers, iron sulphide, dil. sulphuric acid, litmus paper and lead acetate.

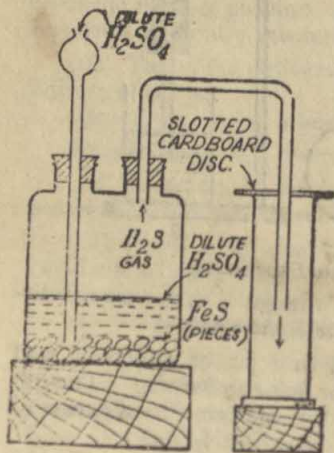


Fig. 21. Lab. preparation of H_2S gas.

Procedure. Place pieces of iron sulphide in a Woulf's bottle and fit the apparatus as shown in diagram. Add sufficient water to cover the lower end of the thistle funnel. Pour slowly some sulphuric acid through the thistle funnel. A reaction starts as soon as the contact between FeS and H_2SO_4 is established. Collect a few jars of the gas by upward displacement of air method. To find out whether the cylinder is full of gas or not, bring a lead acetate paper near the mouth of the gas. If it turns black, the cylinder is full of gas.

Precautions. (i) The apparatus should be air-tight.

(ii) The lower end of the thistle funnel should be always dipped in solution.

(iii) Use slotted disc while collecting gas.

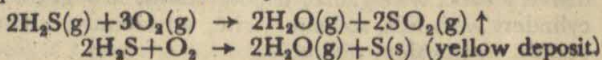
(iv) Do not allow the gas to go waste and pass it through water.

Properties. (i) Note the colour of the gas. It is colourless.

(ii) Smell it from a distance ; it possesses a *smell of rotten eggs*.

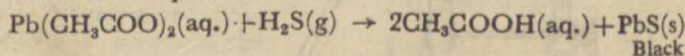
(iii) Invert a jar containing the gas into water. Water rises in the jar indicating that it is *soluble in water*.

(iv) Introduce a burning match stick in jar containing H_2S and observe that stick extinguishes whereas the gas burns with a *pale blue flame* producing a smell of sulphur dioxide. A yellow deposit is also seen in the jar.

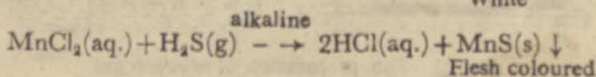
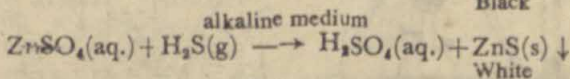
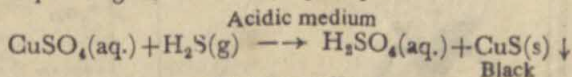


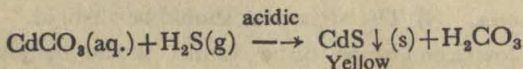
(v) Put a moist blue litmus paper in a jar containing gas. It will turn red indicating *acidic nature* of the gas.

(vi) Bring a piece of filter paper moistened with *lead acetate* solution near the mouth of gas jar. It turns *black* due to formation of lead sulphide.



(vii) Pass H_2S gas through different acidic and alkaline solutions of metals in separate test tubes. Note that sulphides of the corresponding metals will be precipitated.

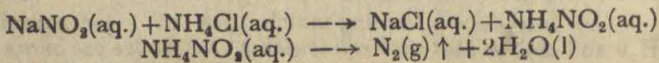




(viii) It reduces KMnO_4 , $\text{K}_2\text{Cr}_2\text{O}_7$, HNO_3 solutions. Pass the gas through (a) acidified KMnO_4 solution (b) acidified $\text{K}_2\text{Cr}_2\text{O}_7$ solution and dil. HNO_3 and note the changes. KMnO_4 solution will get decolourised. $\text{K}_2\text{Cr}_2\text{O}_7$ solution will turn green and in nitric acid 'S' will be precipitated.

5. NITROGEN GAS (N_2)

Nitrogen is prepared by heating a concentrated solution of sodium nitrite and ammonium chloride. Ammonium nitrite is first formed and decomposes on heating to yield nitrogen and water.



Requirements. A round-bottom flask, cork with hole, delivery tube, wire gauze, tripod stand, trough, beehive shelf, cylinders with lids, sodium nitrite, ammonium chloride, litmus papers, magnesium ribbon, etc.

Procedure. Take about 15 gm. of sodium nitrite and 20 gm. of ammonium chloride in a round-bottom flask.

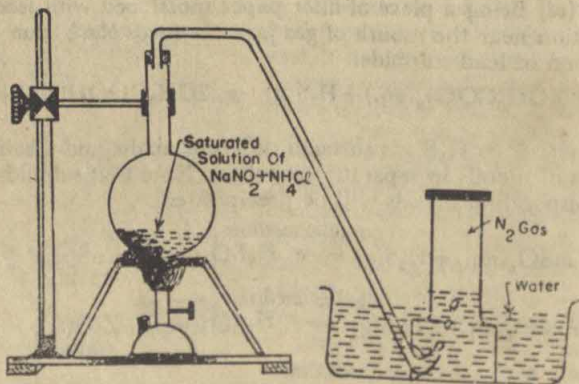


Fig. 22. Lab. preparation of nitrogen gas.

Dissolve these in minimum amount of water. Fit up the apparatus as shown in Fig. 22. Heat the flask gently. Allow first few bubbles to escape. Collect the gas over water by downward displacement of gas.

Precautions. (i) Take ammonium chloride in excess, otherwise explosion is likely to occur.

(ii) Heat the flask very gently.

(iii) Apparatus should be air-tight.

(iv) First remove the delivery tube from water and then stop heating, otherwise there may be back suction of water.

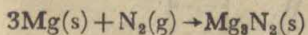
Properties. (i) Look through the jar of the gas and note that it is colourless.

(ii) Smell the gas. Note that it is odourless.

(iii) The method of collection of gas indicates that it is insoluble in water and lighter than air.

(iv) Introduce a burning splinter into a jar containing nitrogen. It stops burning showing that it neither burns nor supports combustion.

(v) Introduce a burning magnesium ribbon in a jar containing nitrogen gas. The ribbon will continue to burn due to formation of magnesium nitride.



(vi) Put moistened blue and red litmus papers in the gas jars. Note that these remain unaffected showing thereby that it is neutral in character.

(vii) Pour acidified KMnO_4 and acidified $\text{K}_2\text{Cr}_2\text{O}_7$ solution in two separate gas jars and shake. Observe that there will be no change, showing no reducing property associated with nitrogen.

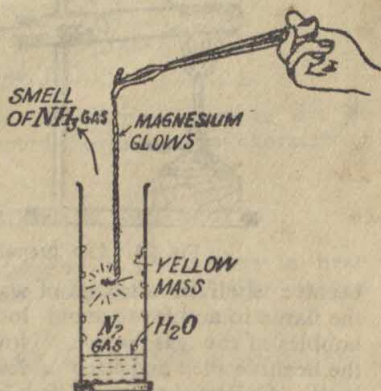
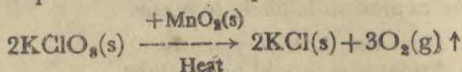


Fig. 23. Introducing burning Mg-ribbon in Nitrogen gas.

6. OXYGEN GAS (O_2)

Oxygen is prepared in the laboratory by heating a mixture of potassium chlorate and manganese dioxide in a ratio of 4 : 1. Manganese dioxide acts as a catalyst and helps potassium chlorate to decompose at a lower temperature.



Requirements. A hard glass tube, cork with a single hole, delivery tube, iron stand, water trough, beehive shelf, gas jars with covers, potassium chlorate, manganese dioxide, magnesium ribbon, sulphur, fine iron wire, etc.

Procedure. Fill about $\frac{1}{3}$ of a dry hard glass test tube with a mixture of $KClO_3$ and MnO_2 in the ratio of 4 : 1. Fit up a cork with a delivery tube in its mouth. Fix the tube in an iron stand with its mouth slightly downwards as shown in Fig. 24. Dip the other end of the delivery tube under the

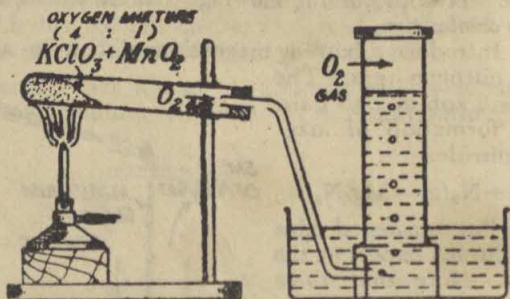


Fig. 24. Lab. preparation of oxygen gas.

beehive shelf in a trough of water. Heat the tube by moving the flame to and fro to avoid localized heating. Let the first bubbles of the gas escape. Now invert a jar full of water over the beehive shelf and keep a few others ready in the trough itself. Collect the gas in a few jars by downward displacement of air and study its properties.

Precautions. (i) Use pure MnO_2 . Impurity of carbon if present, may cause explosion.

(ii) Keep the mouth of the tube downwards.

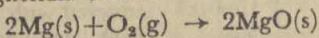
(iii) Disconnect the delivery tube from the test tube before removing the burner.

Properties. (i) Ascertain the colour and odour of the gas by the usual method. Note that it is *colourless* and *odourless*.

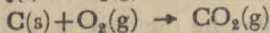
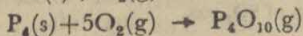
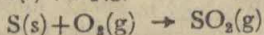
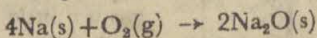
(ii) The method of collection of the gas indicates that it is *insoluble in water* and *lighter than air*.

(iii) Introduce a burning wood splinter into a jar of oxygen. The splinter glows more brightly but the gas itself does not burn. This observation infers that oxygen is *non-combustible* but it is *supporter of combustion*.

(iv) Introduce a burning magnesium ribbon in a jar of oxygen. It burns with a dazzling light producing a white deposit of magnesium oxide.



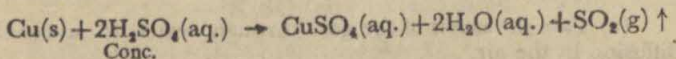
Sodium, sulphur, charcoal, phosphorus burn in oxygen forming their corresponding oxides.



(v) Introduce moist blue and red litmus papers in the jar of oxygen. They remain unaffected showing *neutral* character of oxygen.

7. SULPHUR DIOXIDE GAS (SO_2)

Laboratory preparation of sulphur dioxide consists in heating of copper turnings with conc. sulphuric acid. The reaction involved is



Requirements. A round-bottom flask, cork bored with two holes, thistle funnel, delivery tube bent twice at right

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angles, stand and clamp, gas jars, scrap copper, conc. sulphuric acid, litmus papers, flowers, potassium permanganate, potassium dichromate solution, etc.

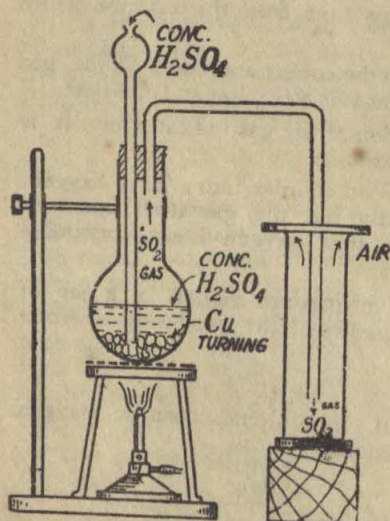


Fig. 25. Lab. preparation of SO_2 gas.

Precautions. (i) Prepare the gas in a fume cupboard, since it makes a great smell.

(ii) Do not inhale the gas.

(iii) Do not heat the flask continuously, otherwise the frothing inside may become beyond control and the liquid may pass to the other end of the delivery tube.

(iv) The lower end of the thistle funnel should be always under the liquid in the flask.

(v) Pass the excess of the gas through water to avoid its diffusion in the air.

Properties. (i) Observe the colour of the gas in the jar. Note that it is colourless.

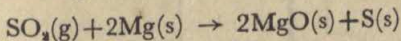
Procedure. Arrange the apparatus as shown in Fig. 25. Pour enough bits of scrap copper in the flask to cover the bottom and pour in conc. sulphuric acid through the thistle funnel till the scrap copper and the lower end of thistle funnel are covered with it. Heat the flask gently and collect the gas by upward displacement of air method. The gas is a little cloudy with acid fumes and this enables to see when the jars are full.

(ii) Open a jar of the gas and wave with your hand a little gas towards your nose. Note that it has a *pungent smell of burning sulphur*.

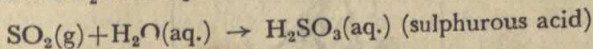
(iii) Invert a jar of the gas in a trough of water. A sudden rise in the level of water inside the gas jar indicates *the high solubility of the gas in water*.

(iv) Introduce a burning match stick in a jar of SO_2 . Note that it extinguishes and the gas does not catch fire. Infer that the gas is *neither combustible nor a supporter of combustion*.

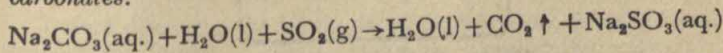
Introduce a burning magnesium ribbon in a jar of SO_2 , it continues burning.



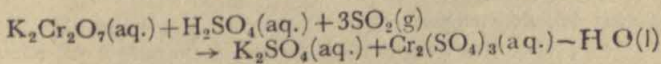
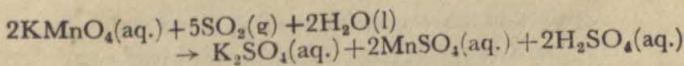
(v) Throw a moist blue litmus paper in a gas jar. Note that the paper turns *red due to sulphurous acid* formed by the action of SO_2 with H_2O .



(vi) Take water extract of Na_2CO_3 in a test tube and pass SO_2 through it. A brisk effervescence owing to the evolution of CO_2 will be seen. Infer that SO_2 *produces effervescence with carbonates*.

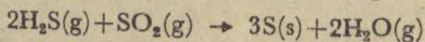


(vii) Bubble sulphur dioxide gas through solutions of acidified potassium permanganate and potassium dichromate separately. Note that permanganate solution gets decolourised and dichromate changes to green. Infer that *gas is strong reducing agent*.



(viii) Invert a jar of SO_2 over another full of hydrogen

sulphide. Observe that yellow powder of sulphur appears in the jar. Infer that SO_2 oxidises H_2S to sulphur.



(ix) Put a moist red flower, such as rose in a jar of gas. Note that the colour of the flower is bleached. Infer that it acts as a bleaching agent.

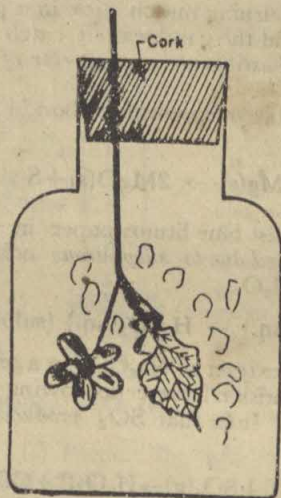


Fig. 26. Bleaching action of SO_2 gas.

CHAPTER 3

QUALITATIVE INORGANIC ANALYSIS

Inorganic salts are the outcome of neutralization of acids with bases or *vice-versa* and combination of acidic oxides with basic oxides. Thus each salt consists of two parts :

One part contributed by acid—acidic radical or anion.

Another part contributed by base—basic radical or cation,

e.g., in sodium chloride, Na^+Cl^- , which can be obtained by the neutralisation of NaOH with HCl , Na^+ is basic radical or cation from NaOH and Cl^- is acidic radical or anionic part from HCl .

Therefore, in order to identify a salt, we have to detect correctly the basic and acidic radical present in it. There are detailed systematic schemes for detection of basic as well as acidic radicals, but without going into those schemes, methods of detection of the radicals included in the syllabus are given in this chapter. *This approach is chosen as only a few salts are in the course and those also to be identified individually.*

Before discussing the methods of identification, some general instructions, following which makes the identification easy, are given below :

1. Never apply any preconceived guess to a test or the result.
2. Always have a set of clean test tubes and clean them after use.
3. Use only small quantity of the reagent at a time.
4. Never carry the general reagents to your seat.
5. Do not change the order of the reagents on the shelves. Replace the bottle on the shelf at its appropriate place.

6. Stoppers of bottles should not be interchanged.

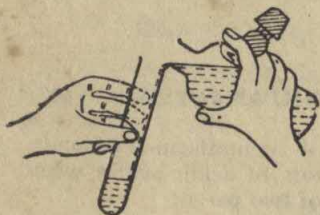


Fig. 27.

7. Never pour back the reagent into stock bottle, once it is taken out.

8. Never place the stopper on the table. Hold the stopper between fingers of the hand in which bottle is held while transferring the reagents.

9. Transfer the reagent from the reagent bottle from the side opposite to the label.

10. Heating of solution should be done properly (as shown in Figs. 28 & 29).

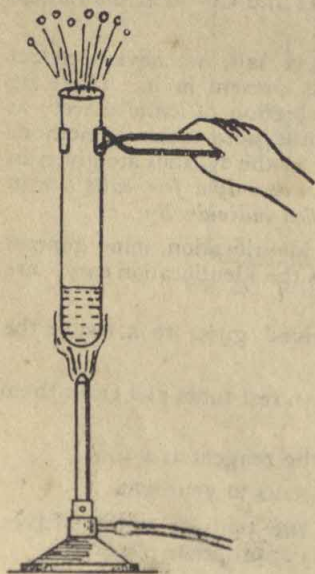


Fig. 28. Wrong way of heating.

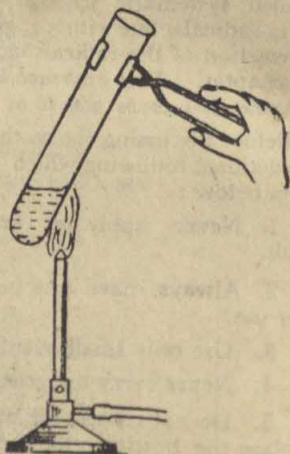
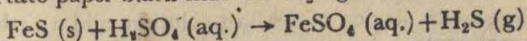


Fig. 29. Proper way of heating.

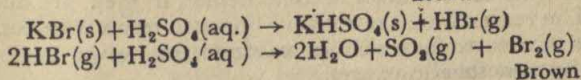
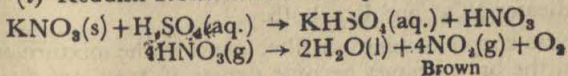
Identification of acid radicals (Cl^- , Br^- , I^- , NO_3^- , PO_4^{3-} and S^{2-}).

1. Take a little of the salt (≈ 0.3 gm.) in a test tube and add about 2 ml. of dil. H_2SO_4 . Observe the change in cold, if no change, heat it. Ascertain the odour and colour of the gas evolved. A colourless gas with smell of rotten eggs and turning lead acetate paper black indicate H_2S gas from S^{2-} .

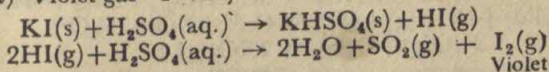


2. Take about 0.5 gm. of the solid salt in a test tube. Add concentrated sulphuric acid and heat the tube gently. Observe the changes if any and proceed in accordance with the following chart :—

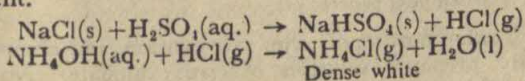
(i) Reddish brown fumes — NO_3^- and Br^- may be



(ii) Violet gas — I^- may be



(iii) Colourless gas with pungent smell giving dense white fumes with a rod dipped in ammonium hydroxide — Cl^- may be present.

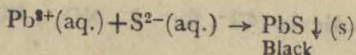


Confirmatory tests

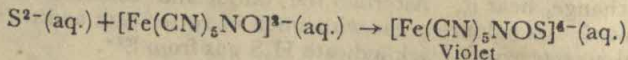
After-finding out the probability of the radical present on the basis of gas evolved, confirm its presence by wet tests. Prepare a solution of the salt in distilled water and test the various anions as :

1. Sulphide (S^{2-})

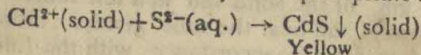
(i) To a little solution of the salt, add one ml. of lead acetate solution. A black precipitate will be formed.



(ii) To another portion of the salt solution, add sodium nitroprusside solution (freshly prepared). A violet colour will be produced.



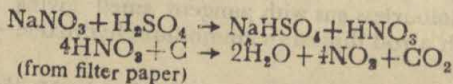
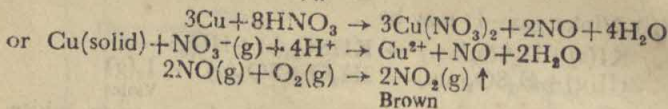
(iii) To a small portion of the salt solution, add a little solid cadmium carbonate. A yellow precipitate indicates sulphide.



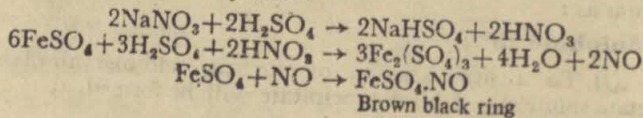
2. Nitrate (NO_3^-)

(i) Brown gas evolved by heating the salt with conc. H_2SO_4 indicates NO_3^- and Br^- both.

Add some copper turnings or filter paper in the mixture and again heat, the brown fumes become denser, if they are due to NO_3^- . The reason is that nitric acid liberated reacts with copper to form nitric oxide which is oxidised to brown nitrogen dioxide by atmospheric oxygen.

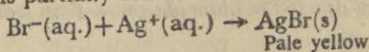


(ii) To a small portion of the salt solution, add about one ml. of freshly prepared solution of ferrous sulphate. Now to this mixture, add conc. sulphuric acid along the sides of the tube. A brown-black ring will be formed at the junction of two layers due to formation of $[\text{FeSO}_4\cdot\text{NO}]$. Acid should be added very carefully and after addition the mixture should not be shaken, otherwise no ring will be formed.

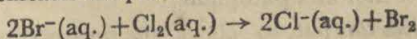


3. Bromide (Br^-)

(i) To a small portion of the salt solution, add silver nitrate solution. A pale yellow precipitate will form. This precipitate is partially soluble in ammonium hydroxide.



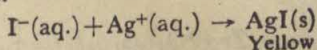
(ii) To a small portion of the salt solution, add about one ml. of carbon disulphide or chloroform or carbon tetrachloride. To this mixture add chlorine water (Cl_2 water should not be very old) drop by drop and shake. An orange colour in the organic layer indicates the presence of bromide.



Br_2 set free, gets dissolved in organic layer giving orange colour to it.

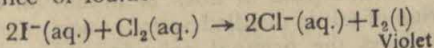
4. Iodide (I^-)

(i) To a small portion of the salt solution, add silver nitrate solution. A yellow precipitate will indicate the presence of iodide.



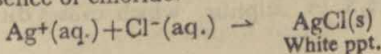
The precipitate so obtained is insoluble in ammonium hydroxide solution.

(ii) To a small portion of the salt solution, add a little of carbon disulphide or chloroform or carbon tetrachloride. To this mixture, add Cl_2 water drop by drop and shake the solution after each addition. A violet colour in the organic layer confirms the presence of iodide.

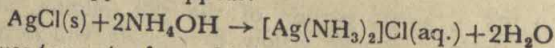


5. Chloride (Cl^-)

To a small portion of the salt solution, add silver nitrate solution. The formation of curdy white precipitate will indicate the presence of chloride.



The ppt. is soluble in ammonium hydroxide and on adding dil. HNO_3 , the ppts. reappear.



Do not use tap water for making the salt solution, otherwise white ppt. will be obtained due to the chloride present in water. Always use distilled water.

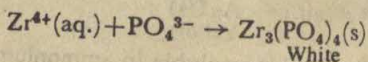
6. Phosphate (PO_4^{3-})

(i) To a small portion of the salt solution, add about one ml. of nitric acid and about 0.2 gm. of ammonium molybdate. Warm the mixture, a canary yellow precipitate of ammonium phospho molybdate indicates phosphate.

Arsenic also gives this test, so check the presence of arsenic (as discussed under cations).

(ii) To another portion of the salt solution, add a little of magnesia mixture. A white precipitate of magnesium ammonium phosphate indicates the presence of phosphate.

(iii) To a small portion of salt solution, add zirconium nitrate solution in nitric acid, a white precipitate indicates phosphate.



Detection of basic radicals (Pb^{2+} , As^{3+} , Sn^{4+} , Cu^{2+})

For the execution of tests for basic radicals, the preparation of the solution of the salt is of utmost importance. Different solvents have to be tried in case the salt defies dissolution in water - cold and hot, but radicals in your syllabus are such that they dissolve in water (cold or hot) or in mineral acids. So prepare a solution of salt in distilled water or acids and stock it. This stock is called the original solution and is abbreviated as O.S.

If the salt has been dissolved in conc. HCl or HNO_3 , all the HNO_3 and HCl must be removed by evaporation to dryness and the dry residue should be extracted with distilled water, otherwise nitric acid oxidises H_2S to sulphur, which causes difficulty in identification.

Acidify about 5 ml. of O.S. with dil. HCl and pass H_2S gas through it. Note the colour of the precipitate.

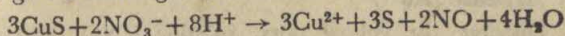
Black ppts. $\rightarrow Pb^{2+}$ and Cu^{2+}
 Bright yellow ppts. $\rightarrow As^{3+}$
 Dirty yellow ppts. $\rightarrow Sn^{4+}$

Arsenic gets precipitated only in hot solution, so warm the solution, if no ppt. in cold.

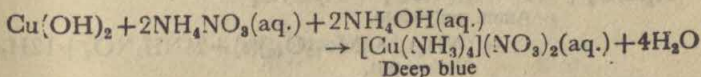
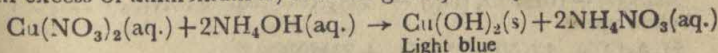
(I) If the ppts. are black, wash them thoroughly with water and dissolve in warm 50% nitric acid. Test the solution for Cu^{2+} or Pb^{2+} as given below :

Copper (Cu^{2+})

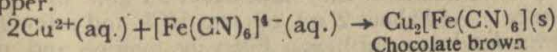
(i) Note the colour of the solution. CuS ppts. dissolve in HNO_3 to give a bluish green solution.



(ii) To a portion of the solution (one ml.), add ammonium hydroxide drop by drop. Light blue ppts. first formed dissolve in excess of ammonium hydroxide giving a deep blue solution.

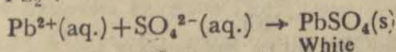


(ii) Acidify another portion with acetic acid and add potassium ferrocyanide solution. A chocolate brown ppt. confirms copper.



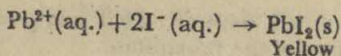
Lead (Pb^{2+})

(i) To black ppt. solution, add dil. H_2SO_4 , a white ppt. indicates Pb_2^{+} .

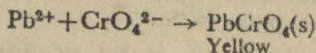


(ii) Dissolve the white ppt. obtained above in a solution of ammonium acetate and divide it into two parts.

Add a solution of potassium iodide to one part. A yellow ppt. confirms Pb^{2+} .



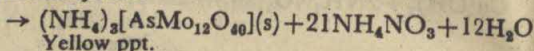
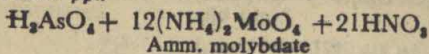
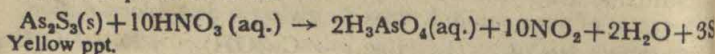
To the second part, add potassium chromate solution. A yellow ppt. confirms Pb^{2+} .



(II) If yellow ppis. come after passing H_2S gas through O.S. + dil. HCl , then either As^{3+} or Sn^{4+} is present. To confirm which of the two (As^{3+} or Sn^{4+}) is present, wash the yellow ppis. with boiling water and then dissolve in conc. hydrochloric acid. Dissolution of ppis. indicate Sn^{4+} , while a bright yellow residue shows the presence of As^{3+} . Confirm the presence of As^{3+} and Sn^{4+} by following tests :

(i) **Arsenic (As^{3+})**

Dissolve the yellow ppis. in conc. HNO_3 , add ammonium molybdate solution and warm the contents. A yellow ppt. confirms the presence of As^{3+} .

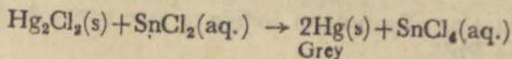
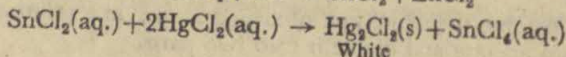
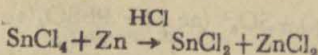


Amm. arsenomolybdate

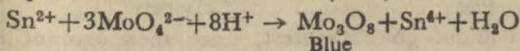
(ii) **Tin (Sn^{4+})**

For the confirmation of Sn^{4+} take about 0.1 gm. of the salt in a test tube. Add about 2 ml. of conc. HCl and a few pieces of pure *granulated* zinc and heat. Filter the solution and divide the filtrate in two parts.

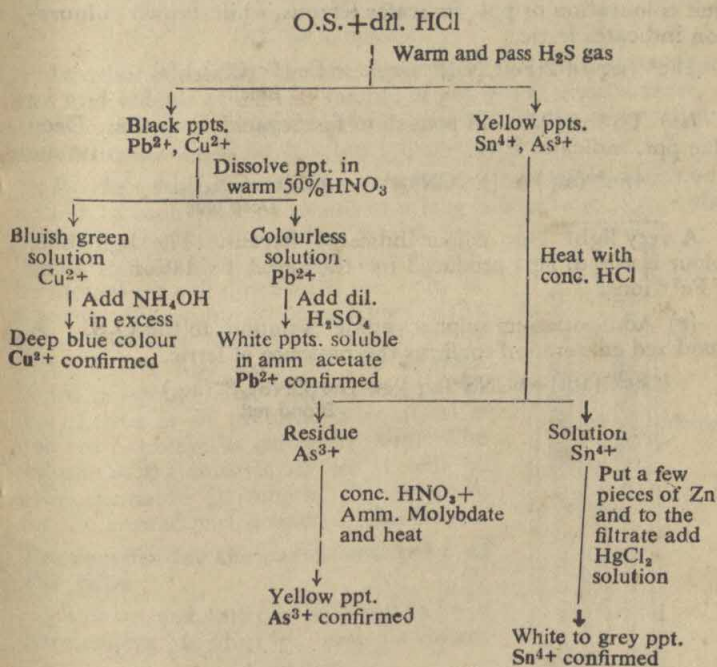
(a) To one part, add mercuric chloride solution ; a white ppt. finally turning to grey will form.



(b) To the second part, add ammonium molybdate solution, a deep blue colour confirms tin (Sn^{4+}).



The above procedure in short is given in the following chart :—

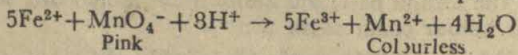


Distinction between Ferrous (Fe^{2+}) and Ferric (Fe^{3+})

(i) To the C S., add ammonium hydroxide ; a reddish brown ppt. indicates ferric, while a light green ppt. indicates ferrous.

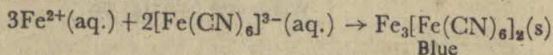
(ii) To about one ml. of O.S., add acidified potassium permanganate solution. Decolourisation of permanganate colour

indicates ferrous (Fe^{2+}). Permanganate oxidises ferrous ions to ferric ions getting itself reduced to colourless compound.

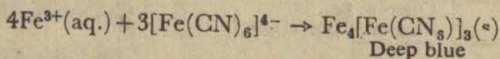


Ferric ions will not give this test, since these cannot be further oxidised.

(iii) Add potassium ferricyanide solution to the O.S. Deep blue colouration or ppt. indicates ferrous, while brown colouration indicates ferric.

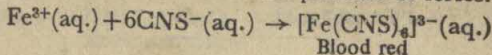


(iv) To the O.S. add potassium ferrocyanide solution. Deep blue ppt. indicates ferric.



A very light blue colour indicates ferrous. The light blue colour is due to Fe^{3+} produced by the aerial oxidation of some of Fe^{2+} ions.

(v) Add potassium sulphocyanide solution to the O.S. A blood red colouration confirms the presence of ferric.



BOYLE'S LAW

Boyle's law states that at constant temperature, the volume of a given sample of gas varies inversely as its pressure. If 'P' denotes the pressure and 'V' the volume of a given sample of gas, the law can be mathematically expressed as

$$P \propto \frac{1}{V}$$

or $PV = \text{constant.}$

In other words, at constant temperature, the multiple of pressure and volume of a given sample of gas will always be same.

The law can be experimentally verified with the help of an apparatus known as Boyle's law apparatus.

Boyle's law apparatus. It consists of two glass tubes connected to each other by means of a long rubber tube. One tube is fixed on a vertical wooden board and its one end is also closed. Other tube can be moved up and down with the help of a screw. The rubber tube and part of the glass tubes are filled with mercury. A metre rod is also fixed on the wooden board between the two glass tubes. The closed tube is of uniform bore (usually one cm) except its curvature top. The volume of the enclosed air in it will be proportional to its length, if correction for the curved part is made in the length.

Correction for the curvature part of the tube :

The curved part can be taken to be a hemisphere of radius 'r', and its volume

$$= \frac{1}{2} \times \frac{4}{3} \pi r^3$$

$$[\therefore \text{vol. of a sphere} = \frac{4}{3} \pi r^3]$$

If this curvature is not taken into account, then what we are considering that the curvature part of the tube is a cylinder of length 'r' and cross-sectional area πr^2 , and volume of air enclosed in this way will be $= \pi r^2 \times r = \pi r^3$

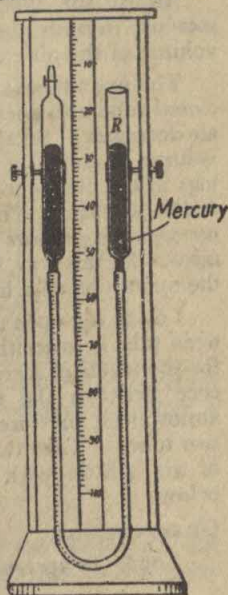


Fig. 30. Boyle's law apparatus.

But the actual volume is $\frac{4}{3}\pi r^3$, hence the error in volume is $\pi r^3 - \frac{2}{3}\pi r^3 = \frac{1}{3}\pi r^3$ and error in its length = volume \div area
 $= \frac{1}{3}\pi r^3 \div \pi r^2 = \frac{1}{3}r$.

Thus for finding the correct volume in terms of length of the tube $\frac{1}{3}r$ must be subtracted from the observed length.

Verification of Boyle's law :

Set the Boyle's law apparatus vertical with the help of leveling screws at the base.

Note the room temperature and atmospheric pressure from a Fortin's barometer (discussed later on in this chapter). Note the position of the top of the closed tube and the point at which the curvature ends with the help of a set square on the metre rod. Difference of two readings will give ' r '.

Adjust the tubes of the Boyle's law apparatus such that mercury in both the tubes stands at the same level. Read the volume of the air enclosed in the closed tube directly.

The open tube is now moved up, when the mercury in the closed tube also goes up a little, i.e., the volume of the enclosed air decreases. When the mercury column becomes steady, the volume of air in the closed tube is read again. Note the readings in the open and closed tube and find the difference of levels in the two tubes. The corresponding pressure in this case will be atmospheric pressure plus difference of level of mercury in the two tubes. In this way, a number of readings are taken by moving the open tube up a little each time.

Lower the open tube such that the level of mercury in the open tube is lower than in the closed tube. Note the readings for the levels of mercury in both the tubes and find the difference between the two. The corresponding pressure will be atmospheric pressure minus difference of level of mercury in the two tubes. Take two more readings by increasing the volume of air a little each time. Record your observations as given below.

Observations :

Room temperature = (i) In the beginning..... °C
 (ii) At the end..... °C

Atmospheric pressure (P_A) = cm. of Hg.

Reading at the top of the closed tube = l cm. (say)

Reading of point where curvature ends = cm.

Difference = r cm.

Correction to be applied on account of the curvature = $\frac{1}{3}r$

S. No.	Position of mer- cury level in		Difference in level $h = l_1 - l_2$	Total pressure of air $P = P_A + \frac{h}{13.6}$	Volume of air in terms of length $V = l - l_2 - \frac{1}{3}r$	PV
	Open tube (l_1)	Closed tube (l_2)				
1.						
2.						
3.						
4.						
5.						
6.						

Since from the above Table it is inferred that PV is constant at room temperature, hence Boyle's law is verified. Further a graph of P vs. $1/V$ gives a straight line.

Precautions :

- (i) The apparatus must be vertical.
- (ii) While changing the volume of air, the reading should be taken after having waited for some time so that the temperature remains constant.
- (iii) Barometer should be accurately adjusted for taking the atmospheric pressure.

How to read atmospheric pressure on a Fortin's barometer :

Determine the vernier constant $\left(\frac{1 \text{ scale division}}{\text{No. of vernier divisions}} \right)$ of the barometer. Turn the screw of the barometer so that the level of mercury in the cistern is lower than the tip of ivory peg and the ivory peg is clearly visible. Adjust the surface of mercury with the help of screw, such that it just touches the tip

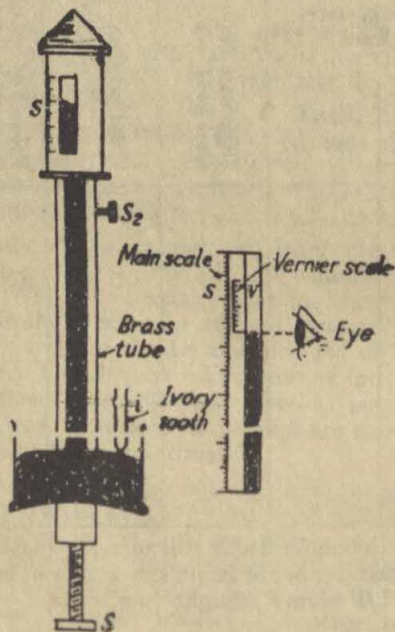


Fig. 31. Reading of Barometer.

of the ivory peg. Now make the vernier adjustment. Rotate the vernier screw so that the vernier scale moves up, much above the mercury level, and bring it down so that zero of the vernier is just in line with the upper surface of the mercury. Note the main scale reading and the vernier scale reading. The sum of the two will give atmospheric pressure in cm. of Hg.

CHAPTER 5

SOLUBILITY

Determination of the solubility of some simple salts in water at room temperature :

Dissolve some common salt (sodium chloride) in water kept in a beaker. Add some more solid and stir the solution, it will also dissolve. Go on adding more and more of the salt until no more of the salt dissolves, i.e., some salt will remain undissolved. This solution is known as *saturated solution* and is defined as a solution which cannot dissolve more of the solid at a given temperature. The capacity of the salt to dissolve in water is known as its solubility. Solubility of a substance is defined as the amount of the substance dissolved in 100 gm. of the liquid so as to give a saturated solution at a particular temperature.

The determination of the solubility of a solid in a liquid consists in preparing a saturated solution at a particular temperature and then determining the composition of the solution at that temperature. Solubility is very much dependent on the temperature, so that temperature must be mentioned at which the solubility is determined.

Procedure. Note the room temperature (say 30°C). Prepare a saturated solution of the solid, whose solubility is to be determined, at $35\text{--}36^{\circ}\text{C}$. To prepare the saturated solution, take in a beaker about 100 ml. of water. Heat it on a wire gauze to $35\text{--}36^{\circ}\text{C}$. Add to it, in small quantities, finely powdered solid with constant stirring until some solid remains undissolved. Allow this solution to cool down. On cooling excess of the solid separates out. Filter it off through filter paper and collect the filtrate in a clean beaker. Pipette out 10 ml. of this filtrate in previously weighed porcelain dish and weigh the dish again along with the solution. Evaporate the solution over a water bath until only dry residue is left in the dish. Allow the dish to cool and take its weight. Calculate the solubility of the substance at room temperature as given on the next page :

Room temperature

 $= 30^{\circ}\text{C}$ (say)

Weight of the dish

 $= x \text{ gm.}$ 

Fig. 32. Drying over water bath.

Weight of the dish + solution $= y \text{ gm.}$ Weight of the dish + residue $= z \text{ gm.}$ Solubility $= \frac{(\text{Weight of the solid})}{[\text{Weight of the solvent (water)}]} \times 100 \text{ gm.}$ Weight of the solid $= (\text{Wt. of the dish + residue}) - (\text{Wt. of the dish})$ *i.e.,* $= z - x$ Wt. of the solvent (water) $= (\text{Wt. of the dish + solution}) - (\text{Wt. of the dish + residue})$ *i.e.,* $= y - z$

Therefore, solubility of the substance

$$= \frac{z - x}{y - z} \times 100 \text{ gm.}$$

at room temp. (30°C)

CHAPTER 6

RATE STUDY OF REACTIONS

Rate study of the reaction between HCl and marble :

The rate of reaction is defined as *the mass of reacting material changed or product formed (in gram molecular weight) in unit time*. It depends upon (i) nature, both physical as well as chemical, of the reacting substance ; (ii) temperature at which reaction is carried out ; (iii) concentration of the reacting substances ; and (iv) medium in which reaction is carried out.

How these factors affect the rates of reaction can be investigated experimentally.

The procedure for studying the effect of concentration of reactants is given below :—

A. Effect of different concentrations of hydrochloric acid on its action on marble :

Prepare five solutions of different concentrations of hydrochloric acid. In a simple way these can be prepared by taking 5 ml., 10 ml., 15 ml., 20 ml. and 25 ml. of concentrated hydrochloric acid in five different beakers marked 1, 2, 3, 4 and 5 respectively and then diluting the volume of each to 50 ml. by adding distilled water. Now weigh five samples of powdered marble, each equal to one gram. Put one sample in first solution (i.e. Beaker No. 1) and immediately start the stop watch. Note the time taken for complete dissolution of marble. Similarly note the time taken for the complete dissolution of marble in other cases also.

Record your data as

Weight of the marble taken each time = one gm.

Temperature =°C

<i>S. No.</i>	<i>Conc. of Hydrochloric Acid</i>	<i>Time taken for complete dissolution in sec.</i>
1.	1.13 N or 3.5 %
2.	2.26 N or 7.0 %
3.	3.39 N or 10.5 %
4.	4.52 N or 14.0 %
5.	5.65 N or 17.5 %

On comparing the time of complete dissolution, you will find that time decreases as the concentration of acid increases. In other words, the rate of reaction increases with the increase in concentration, since by definition, rate of reaction is the mass of the reacting material changed in unit time and as mass of the reacting material (marble) changed is same in all the reactions, so less the time taken, faster will be the rate of the reaction.

B. Effect of different concentrations of hydrochloric acid on its action on zinc can be investigated in a similar way.

CHAPTER 7

CALORIFIC VALUE OF FUELS

Determination of the calorific value of some volatile combustible substances :

A large number of combustible substances are now-a-days in use as fuels. How they are graded or how you can compare different fuels with respect to their efficiency? The fuels are graded on the basis of their calorific values; higher the calorific value of a combustible substance, better it is as fuel. Calorific value of a substance is defined as the amount of heat generated (in calories), when one gram of it is burnt.

To determine the calorific value of spirit :

Requirements. Calorimeter with stirrer, thermometer, spirit lamp, tripod stand, perforated tin cone, balance and weight box.

Procedure. Weigh an empty calorimeter with stirrer. Fill it $2/3$ with water and again weigh it. Thus weight of water can be obtained by difference. Note the temperature of water. Fill the spirit lamp with spirit and weigh the spirit lamp along with spirit. Place the spirit lamp under the calorimeter resting on a tripod stand. Surround the spirit lamp and the calorimeter with a perforated tin cone. Light the spirit lamp and let it burn till the temperature of water rises by about $10-15^{\circ}\text{C}$. Extinguish the flame and note the maximum temperature attained by water. Weigh the spirit lamp again. The difference of the two weights of spirit lamp will give the amount of spirit consumed. Record your observations as follows : -

- (i) Weight of the calorimeter with stirrer $= W_1$ gm.
- (ii) Weight of the calorimeter with stirrer + water $= W_2$ gm.
- (iii) Weight of the spirit lamp before lighting $= W_3$ gm.

- (iv) Weight of the spirit lamp after the experiment
i.e., after heating the water $= W_4$ gm.
- (v) Initial temperature of water $= t_1^\circ\text{C}$
- (vi) Final temperature of water $= t_2^\circ\text{C}$

Calculations :

Weight of the water (W_5) $= W_3 - W_1$ gm.

Weight of the spirit consumed or burnt (W_6) $= W_3 - W_4$ gm.

Rise in temperature $= t = t_2 - t_1^\circ\text{C}$

Now Heat gained by water

$= \text{mass of water} \times \text{specific heat of water} \times \text{rise in temperature}$

Neglecting the heat gained by calorimeter which is very small as compared to heat gained by water.

$= W_5 \times 1 \times t$ calories [\because sp. heat of water $= 1$]

\therefore Calorific value of spirit $= \frac{W_5 \times 1 \times t}{W_6}$ cal./g

Calorific values of other substances can be determined essentially in a similar manner. However for greater accuracy, heat gained by the calorimeter should also be taken into account. If it is taken into account then total heat gained $= W \times t + W_5 \times t$ calories, where ' W ' is the water equivalent of the calorimeter.

$W = \text{mass of the calorimeter} \times \text{sp. heat.}$

Precautions : (i) The final temperature should be noted after stirring the water.

(ii) Temperature should be correctly noted.

(iii) The calorimeter should be covered with a lid when water in the calorimeter is stirred.

CHAPTER 8

ORGANIC ANALYSIS

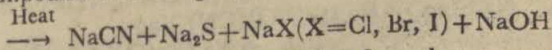
More than 4,00,000 organic compounds have been recorded in the literature today. Most of these may be grouped into a comparatively small number of homologous series or classes of organic substances like alcohols—compounds with $-\text{OH}$ groups; aldehydes and ketones—compounds with $>\text{C}=\text{O}$ group; amines—compounds with $-\text{NH}_2$ grouping, etc. By identifying the class to which an organic compound belongs, the problem of characterisation of a compound is enormously simplified. Thus testing of these functional groups plays a significant role in identifying an organic compound.

Besides C, H and O, an organic compound may contain halogen, nitrogen or sulphur. So detection of these elements in organic compounds also helps in ascertaining the class of the organic substance. In this chapter you will find methods of detection of these extra elements and tests for some functional groups.

I. Detection of Cl, Br, I, N and S in organic compounds :

In order to detect these elements in organic compounds, it is necessary to convert them into ionisable inorganic substances, so that the usual test of inorganic qualitative analysis may be applied. This conversion may be accomplished by several methods but the best procedure is to fuse the organic compound with metallic sodium (*Lassaigne's test*). In this way sodium cyanide, sodium sulphide and sodium halides are formed, which are readily identified.

Organic compound containing C, H, O, S, N, Hal. + Na



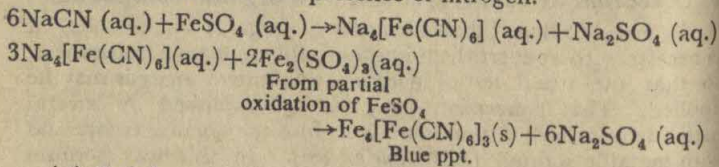
If N and S both are present then NaCNS is formed.

Support a small, soft glass test tube (ignition tube) in a clamp. Place a cube of freshly cut sodium (0.04 gm.) in the tube. Heat

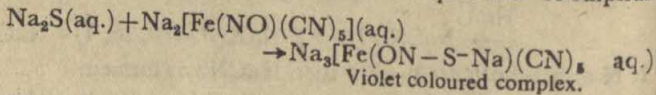
the tube gently. When sodium melts and forms a globule, a rice grain of substance (~ 0.05 gm.) if solid or three drops of liquid, is added and the reaction is allowed to proceed. Now remove the tube from the clamp and hold it by means of a pair of tongs. Heat it carefully at first, then strongly until the entire lower end of the tube is red hot and maintain it at this temperature for a minute or two. Plunge the tube while still hot into a china dish containing about 10 ml. of distilled water, and cover the dish immediately with a wire gauze. The tube will be broken and the residual sodium will react with the water. *Never take large amount of sodium metal and also see the sodium reacts almost completely.* When the reaction is over, heat to boiling and filter. The filtrate should be clear and alkaline. If it is dark coloured, decomposition was probably incomplete and repeat the entire process again.

The filtrate is tested for various extra elements as follows, taking every time a fresh solution :

(i) **Nitrogen.** To about one ml. of sodium fusion extract i.e., filtrate, add one ml. of freshly prepared solution of ferrous sulphate. Heat the mixture gently with shaking until it boils, then, without cooling add just sufficient dilute sulphuric acid to dissolve the iron hydroxide formed. *A prussian blue precipitate or colouration* indicates the presence of nitrogen.

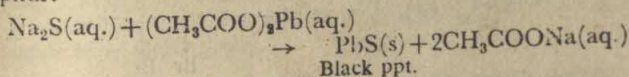


(ii) **Sulphur.** Add about one ml. of freshly prepared solution of sodium nitroprusside to about 2 ml. of sodium fusion extract. *A violet colouration* confirms the presence of sulphur.



Take about one ml. of the fusion extract, acidify it with dilute acetic acid and add a few drops of lead acetate solution.

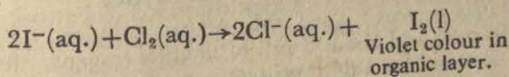
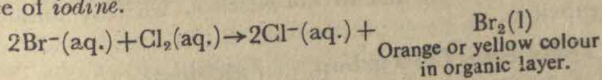
A black precipitate of lead sulphide indicates the presence of sulphur.



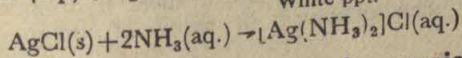
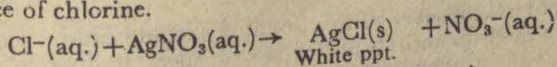
(iii) Halogens (Cl, Br, I)

Take 2 ml. of fusion extract, acidify with dil. acetic acid and add one ml. of carbon tetrachloride or carbon disulphide or chloroform. Then add Cl_2 water drop by drop with constant shaking.

A brown or yellow colour in organic layer indicates the presence of bromine, while a violet or purple colour will indicate the presence of iodine.



For detecting chlorine, take about 2 ml. of fusion extract, add one ml. of conc. HNO_3 . Boil, cool and add silver nitrate solution. A curdy white precipitate soluble in excess of ammonium hydroxide and insoluble in nitric acid confirms the presence of chlorine.

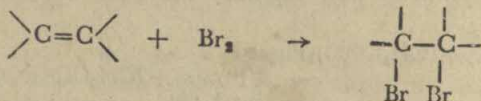


II. Tests for functional groups in organic compounds :

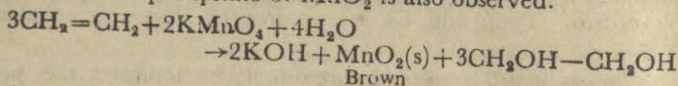
1. Testing of unsaturation and saturation :

(i) Addition of bromine may be used as a test for the presence of double bond, i.e., unsaturation.

Dissolve 0.2 gm. or 0.2 ml. of the compound in 2 ml. of carbon tetrachloride, and add a few drops of 20% solution of bromine in carbon tetrachloride. If the colour of bromine disappears, unsaturation is there. The colour of bromine is destroyed, because the organic dibromide is produced.



(ii) Dissolve 0.2 gm. or 0.2 ml. of the substance in 2 ml. of water or acetone and add 4-5 drops of 2% potassium permanganate solution dropwise. Decolourisation of it indicates unsaturation. A brown precipitate of MnO_2 is also observed.



(iii) Saturated hydrocarbons do not react with cold concentrated sulphuric acid and are *not miscible*, whereas unsaturated are miscible.

2. Tests for $-\text{CHO}$ group, i.e., aldehydes :

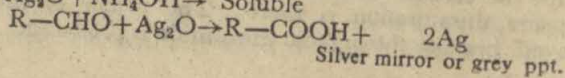
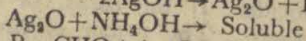
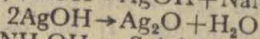
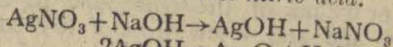
(a) *Schiff's reagent* : To 2 ml. of aq. solution of original substance in cold, add about 3 ml. of Schiff's reagent, shake well and allow to stand for *half a minute*. A pink colour indicates the presence of aldehyde.

Schiff's reagent is prepared by dissolving rosaniline hydrochloride in water, when a pink colour solution is produced ; the solution is decolourised by passing sulphur dioxide gas through it.

(b) Take 3 ml. of silver nitrate solution and add caustic soda solution drop by drop until a precipitate of silver hydroxide is obtained which is then dissolved in excess of ammonium hydroxide.

To a portion of above solution, add about 5 drops of the substance and keep the tube in a hot water bath. Appearance of a silver mirror or greyish black precipitate indicate aldehyde.

After the test, pour the contents of the test tube into the sink and wash the test tube with dilute nitric acid.



(iii) To about 2 ml. of the aqueous solution of the compound, add one ml. of Fehling's solution and warm the content on a water bath for a few minutes. Red precipitate indicates the presence of $-\text{CHO}$ group.

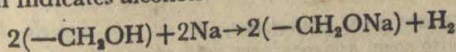
Fehling's solution is prepared by mixing equal volumes of solutions A and B.

Fehling Solution A—Dissolve 17.3 gm. of copper sulphate in 250 ml. of water containing a few drops of dil. H_2SO_4 .

Fehling Solution B—Dissolve 8.65 gm. of sodium potassium tartrate and 35 gm. of caustic soda in 250 ml. of water.

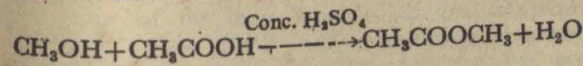
3. Test of $-\text{CH}_2\text{OH}$ group (Alcohols) :

(i) Take about 2 ml. of the substance in an *absolutely dry test tube*, add a small quantity of anhydrous sodium sulphate to absorb moisture and filter into another dry test tube. Now add a small piece of sodium to it. Effervescence with evolution of hydrogen indicates alcohols.



(ii) To about one ml. of the substance in a test tube add a few drops of ceric ammonium nitrate solution. Appearance of red colour indicates the presence of alcohols.

(iii) Take a few drops of the compound in a test tube, add a few drops of acetic acid and a drop of concentrated sulphuric acid. Warm and smell. A characteristic *pleasant smell* due to formation of ester indicates alcohol.

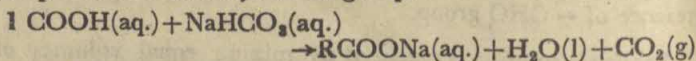


4. Test of $-\text{COOH}$ group (Carboxylic Acid) :

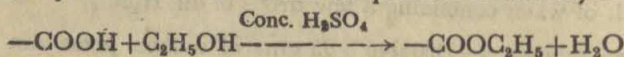
(i) Place a small quantity of the substance on a piece of moist blue litmus paper, if the colour changes to red, carboxylic group may be present.

(ii) To 5 ml. of cold 10% solution of sodium bicarbonate add a pinch of substance if solid and few drops if liquid—strong

effervescence with the evolution of carbon dioxide gas indicates the presence of carboxylic acid group.

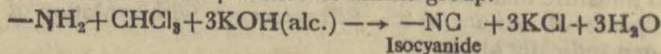


(iii) To a small quantity of substance add 5 drops of ethyl alcohol and two drops of concentrated sulphuric acid. Warm. A fruity smell of ester indicates the presence of carboxylic group.



5. Test of ---NH_2 group (Amines) :

(i) *Carbylamine test* : Take a small amount of substance in a test tube, add one ml. of concentrated hydrochloric acid and a few drops of chloroform. Then add about 2 ml. of alcoholic solution of potassium hydroxide and warm. A very offensive smell indicates the presence of amino group.



Isocyanides are very poisonous, so do not inhale them and destroy them with conc. hydrochloric acid after test.

(ii) Dissolve 1 gm. or one ml. of the substance in 3 ml. conc. hydrochloric acid and 5 ml. of water, and cool the solution into ice. Add a cold solution of 1.0 gm. of sodium nitrite in 5 ml. water slowly and with shaking. To this solution add a cold solution of 0.4 gm. of β -naphthol in 4 ml. of 5% sodium hydroxide solution. Formation of orange-red dye indicates the presence of amines.

CHAPTER 9

MILK, OILS AND FATS

Milk (proteins), oils and fats are our essential meals. Sometimes the things, which we are getting from the market, may not be pure. How to test their purity? However, a detailed discussion of the subject is beyond the scope of this book, but a few methods for testing common adulteration are given in this chapter.

Milk. Milk is a colloidal solution of fat, protein, carbohydrates and trace quantity of minerals in water. It is mainly adulterated with

- (i) water and skimmed milk to increase the volume when milk has been sold on a fluid bases.
- (ii) thickness, such as gelatin, starch, calcium succinate, etc. to make cream appear richer.

Detection of Watering or Skimming :

Since the composition of milk is variable, it is difficult to detect watering or skimming, etc. However milk serum or whey, that protein from which both fat and casein have been removed, is quite constant in composition and analysis of it is often used in attempting to detect watering.

One of the most reliable physical constant of milk is its freezing point. Presence of impurities, such as water, skimming agent, gelatin, starch, etc. depress its freezing point, so determination of freezing point will indicate the purity of milk sample. Pure milk freezes between -0.53 to -0.56°C . Milk with water has freezing point close to zero.

Detection of Starch (thickening agent) :

Take 5 ml. of milk in a test tube. Heat it just to boiling point, cool and add a few drops of iodine solution. A blue

colour indicates the presence of starch. If it is pure, then there will be a *deep yellow colouration due to casein*, a protein of the milk.

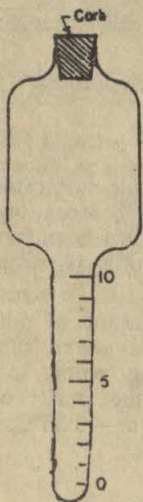
Another test for *casein* is to dissolve it in sodium hydroxide and then adding dropwise a solution of copper sulphate (dilute) when a violet colouration appears.

Detection of Peroxidase in Milk

An alcoholic solution of methylene blue, formaldehyde and water is added to the milk sample. Tube is placed in water bath at 45°C. *In less than 20 minutes the raw milk will decolourise the methylene blue while the pasteurised milk will take much time.*

Babcock test for Purity of Milk

This tests the fat content in milk. About 18 gm. of milk is taken with the help of a pipette in a small narrow-necked graduated flask (as shown in fig.) and sulphuric acid is mixed in it. The flask is shaken until the mixture becomes dark coloured. The acid does not affect the fat but it dissolves other solids in milk. The bottle is then centrifuged by which the fat is forced towards the neck, being lighter than other contents. Sufficient warm water is added to bring the fat in the narrow neck, where its exact percentage is read on the graduation mark.



Flask for measuring fat in milk.

Oils and Fats

Oils and fats are esters of long chain fatty acids and glycerol. Oils are liquid at room temperature and contain more esters of *unsaturated fatty acids* whereas fats are solid at room temperature.

Presence of oils and fats in any material can be detected by crushing a small piece of the test material between the folds of a filter paper. *Appearance of a translucent spot which grows larger on heating indicate their presence.*

How to find out whether the material is oil or fat :

(i) To ascertain whether the material is oil or fat first examine its state. If it is solid, then it is a fat otherwise oil.

(ii) Estimation of unsaturation in the material also tells whether the material is oil or fat, since we know that oils contain more unsaturated fatty acids.

Take some oil or fat. Dissolve it in chloroform and add drop by drop Hubble's iodine solution (a solution of iodine and mercuric chloride) and shake. Decolourisation of iodine solution indicates the presence of unsaturated fatty acids and hence oils and fats. Find out the volume of iodine solution used to give the sample solution the colour of iodine. Oils are more unsaturated and use more of iodine solution.

Adulteration of Oils and Fats

Oils and fats are mostly adulterated with

(1) Dyes—to improve the colour of the material.

(2) Paraffin wax or hydrocarbons—to increase the weight of products (vegetable ghee), thereby increasing the profit.

(3) Cheap varieties of similar materials, *e.g.*, pure ghee is adulterated with vegetable ghee. Detailed discussion of the methods for examining oils and fats for these adulterations is beyond the scope of this book, but a few, which you can easily perform are given below :

(i) *Sp. gravity determination.* Determination of specific gravity of the test sample gives a clue about its purity. Sp. gravity is a unique property of the substance, hence comparison of the sp. gravity of test sample with the sp. gravity of the pure sample gives the purity of the test sample.

(ii) *Detection of dyes in oils and fats.* (a) Take 2 gms. of the melted and filtered fat in a test tube. Add 5 ml. of light petroleum to avoid its solidification and one ml. of hydrochloric acid (1 : 3) to it. Shake the tube thoroughly and allow to stand for some time. Appearance of pink colour in the lower layer will indicate the presence of dyes.

(b) Repeat the above test (a) taking 10% KOH solution instead of hydrochloric acid. This time colourless solution will indicate presence of dyes.

(c) Mix one ml. (\approx 1 gm.) of the fat with one ml. of a mixture of concentrated sulphuric acid and glacial acetic acid (in 1 : 4 ratio) and heat the mixture nearly to boiling. Pink or reddish colour of the solution will indicate presence of dyes.

(iii) *Detection of paraffin wax and hydrocarbons.* Heat small amount of the unsaponifiable matter of oils with acetic anhydride carefully. If small droplets of oil will be found floating on the surface of unused acetic anhydride, then the oil is surely adulterated with paraffin wax or hydrocarbon.

(iv) *Detection of vanaspati ghee in pure ghee.* Take 2 ml. of hydrochloric acid in a test tube. To it add 2-3 drops of a 2% alcoholic solution of furfural and 2 ml. of melted and clear sample of ghee. Shake for two-three minutes and allow the test tube to stand for 5-6 minutes. If pink colour appears vanaspati must be present.

(v) *Detection of cotton-seed oil (Binaula ka tel) in mustard oil* Take 2.5 gm. of the liquefied sample and equal volume of amyl alcohol in a test tube. To it add 2.5 ml. of a 1% solution of sulphur in carbon disulphide and fix a cork in the mouth of tube. Place it in water bath for about 30 minutes. A crimson colour will produce in the presence of cotton-seed oil.

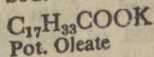
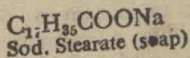
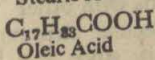
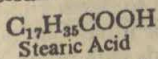
(vi) *Detection of sesame oil (Til oil).* Shake 2 ml. of the oil and one ml. of conc. hydrochloric acid containing 1% sucrose (w/v) for a few minutes and keep aside the tube for five minutes. A brilliant crimson colour indicates sesame oil.

(vii) *Testing of adulteration in Almond oil.* Take 2 ml. of the sample in a test tube. To it add about 0.5 ml. of a freshly prepared mixture of equal weights of water, sulphuric acid and fuming nitric acid and shake the contents. Pure oil does not give any colour change.

CHAPTER 10

SOAP

Soap is the most common cleaning agent, as it does not cause injury to skin and fabric like other cleaning agents. Have you ever thought what is soap? Perhaps you are afraid. Soaps are nothing but alkali salts of higher fatty acids, e.g., washing soap is sodium salt of stearic acid, whereas toilet soap is potassium salt of oleic acid.



After knowing what soap is, you will like to prepare a sample of soap yourself. Here you will find a method to make soap (toilet) in your laboratory. However methods applied for the manufacture of soaps are different but principle is same.

Chemicals required :

Coconut oil = 100 gm.

Castor oil = 20 gm.

Caustic soda lye = 60 gms. (lye—caustic soda dissolved in water)

Colour and scent = sufficient to give required tint and flavour.

Melt and mix the two oils in a beaker. To the mixed oils add the lye slowly and with constant stirring. Stir the mass continuously until a semi-solid mass is obtained. Add scent and colour, allow to stand for some time and then cut the solid into desired shape.

CHAPTER 11

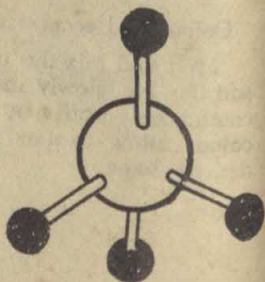
ASSEMBLING THE MODELS OF SOME ORGANIC COMPOUNDS

Organic Chemistry is the study of carbon compounds, of which there are well over 10,00,000. Why is it that carbon, of all elements, is able to form an almost limitless number of compounds? The answer lies in its unique *structure* which allows its atoms to join on to one another to form chains and rings. Carbon has a valency of four, for it has four outer electrons which are used to form covalent bonds with other atoms. The usual method of representing molecular structure of organic compounds is an over simplification, since the formulae are written on a plane surface whereas the actual molecule has three dimensions. The most effective way of representing molecular structure of organic compounds is by means of three dimensional models. Models can be assembled with the help of balls and sticks (made of plastic or wood) or springs. These balls and sticks you can get easily from the market or you can make yourself too. For distinguishing among the different atoms, give different colours to balls, e.g. white—balls representing C-atoms, black-balls representing H-atoms.

Only a detailed procedure for assembling model of methane (simplest and basic of all organic compounds) is given and rest you can assemble yourselves with the help of given diagrams.

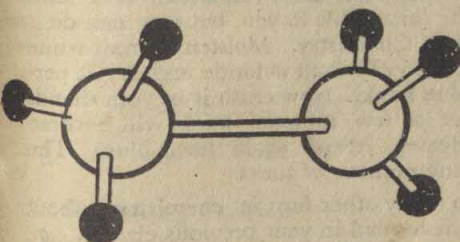
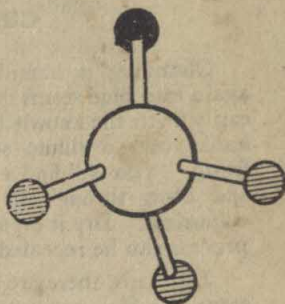
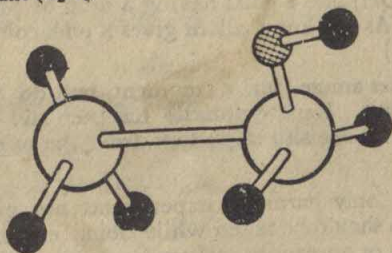
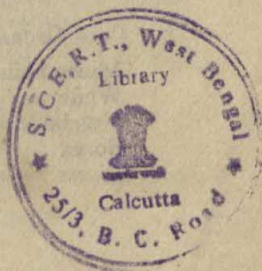
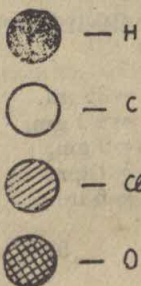
Methane :—The geometrical arrangement of the methane molecule places the four hydrogens at the points of a tetrahedron with the carbon atom at its centre.

Take a ball (white) with four holes in it (angle between two holes $\sim 109^\circ$) and insert four sticks one in each hole. Attach one ball (black)



Methane (CH_4)

at the end of each stick. Each white ball stands for an atom of carbon ; each black ball stands for an atom of hydrogen and each stick represents a single covalent bond.

Ethane (C_2H_6)Chloroform ($CHCl_3$)Ethyl alcohol (C_2H_5OH)

APPENDIX I

CHEMICAL HOBBIES

Changing a blue handkerchief into colourless and then again into blue seems quite impossible to you, but you can do it easily with the knowledge of Chemistry. Moisten a small white hanki into a dilute solution of cobalt chloride and dry it perfectly. You will find a blue hanki. Now crush it in your hands and blow through it for a few minutes, hanki will become colourless. Dry it on a heater, it will again turn blue. The process can be repeated any number of times.

Like this, there are so many other funs in chemistry, about some of which you must have read in your previous classes, *e.g.*, changing water into wine by pouring water containing a little of alkali (NaOH) into a glass having a drop of phenolphthalein previously. (As you know alkali gives a pink colour with phenolphthalein.)

These tricks amuse for a moment but do not have any practical utility. Here emphasis has been laid on certain experiments which are also important from the applied point of view.

Although only harmless experiments are given, but still every caution should be taken while doing experiments involving chemicals or operations, otherwise those might cause some injury.

COSMETICS

1. Cold Cream

Mineral oils	=35 ml.
White wax	=4.5 gm.
Vegetable wax	=9 gm.
Borax	=1 gm.
Water	=6 ml.

The waxes and oil are melted on a water bath and a solution of borax is added to these slowly and with constant stirring. The mixture is then removed from the bath and stirring is continued till the product is cold, smooth and uniform.

To 4 gm. of this mixture is added 6 gm. of a mixture of following powders and the whole mass works to a smooth homogenous cream.

Talc	= 8 gm.
Zinc white	= 2 gm.
Precipitated chalk	= 6.5 gm.

2. Vanishing Creams

Stearic acid	= 100 gm.
Glycerine	= 30 gm.
Water	= 240 ml.
Triethanolamine	= 5 gm.
Phenylacetic acid	= 6 drops.
Benzyl propionate	= 780 gm.
Musk xylene	= 65 gm.
Terpineol	= 2.5 gm.

Melt the stearic acid on a water bath and to it add boiling solution of triethanolamine in water. Stir and add to it a mixture of oils in glycerine. Reduce the whole mass to a homogenous smooth paste.

3. Talcum powder

Talc itself can be used as talcum powder, but you can add some fragrance of your choice to it.

Talc (Hydrated Magnesium Silicate) = 400 gm.

Rose oil = 10 drops

Extract of jasmine = 10 gm.

Talc should be of very fine quality. If it is not, then reduce it by crushing in a mortar and then filtering through a thin cloth. To the talc then mix other ingredients thoroughly and store in some air tight boxes.

4. Lipstick



Fig. 34.

Paraffin wax = 100 gm.

White beeswax = 62 gm.

Cocoa-butter = 25 gm.

White liquid petrolatum = 100 gm.

Vanillin = 5 grains (325 mg.)

I.C.I. colour (oil soluble) = sufficient to give required tint

Melt the waxes together on a water bath. Add the cocoa butter and the white liquid petrolatum and stir to a uniform mass. Remove the heat and add while still stirring the vanillin and colour to the desired tint. Pour it into moulds and allow to harden.

5. Nail polish

Cellulose nitrate = 25 ml.

Dibutyl phthalate = 100 ml.

Acetone = 400 ml.

Butyl acetate = 300 ml.

Ethyl lactate = 100 ml.



Fig. 35.

Eosine (alcoholic solution) = sufficient to give tint.

Dissolve cellulose nitrate in the mixture of acetone, butyl acetate and ethyl lactate and then add other ingredients.

Caution : *There should be no flame in the room, while preparing nail polish.*

6. Nail polish remover :

Amyl acetate = 25 ml.

Acetone = 25 ml.

Castor oil = 5 ml.

Mix all the things and store in a glass bottle. Castor oil keeps the nail soft.

7. Shampoos

Liquid soap = 100 ml.

Water = 90 ml.

Triethylamine
lauryl sulphonate = 10 ml.

Perfume and colour = small quantity.

The above mixture gives a mild shampoo.

Egg shampoo

Whites of 2 eggs

Water = 125 ml.

Ammonia water = 75 ml.

Cologne water = 8 ml.

Alcohol = 100 ml.



Fig. 36.

Beat the egg white to a froth and add the other ingredients in the above order (given) with a thorough mixing after each addition.

8. Hair-curling liquid

Water	=70 ml.
Spirit of wine	=30 ml.
Borax	=2 gm.
Perfume	=sufficient quantity

Dissolve the borax into water and then mix the solution with spirit of wine. Add perfume in the last.

9. Tooth Paste



Fig. 37.

Precipitated chalk	=125 gm.
Magnesium carbonate	=95 gm.
Powdered sugar	=30 gm.
Powdered white soap	=30 gm.
Glycerine	=280 gm.
Water	=280 ml.
Oil of winter green or peppermint	=5 drops

First mix all the powders thoroughly. Filter through a fine cloth and mix glycerine and water. Reduce the whole mass into a homogeneous paste.

10. Oil of Wintergreen (a perfume)

Methyl alcohol = 5 ml.

Sulphuric acid = 1.5 ml.

(Acetyl salicylic acid) Aspirin = one tablet

Add *carefully* sulphuric acid in methyl alcohol. Shake the mixture gently and then add powdered aspirin tablet. Stir a little, stopper the tube with a loose plug of cotton and keep the tube in warm water bath for 15 minutes.

Note : Do not use the product without purification.

11. Fountain Pen Ink

(i) Blue-black Ink

Tannic acid = 20 gm.

Ferrous sulphate = 20 gm.

Gallic acid = 8 gm.

Oxalic acid = 8 gm.

Salicylic acid = 2 gm.

Carbolic acid (phenol) = 5 gm.

Acid blue = 30 gm.

Water to make whole = 4 litres

Dissolve ferrous sulphate in some cold water. Dissolve other ingredients separately in hot water. Mix all the solution with a thorough mixing after each addition. Filter the mixture through a filter cloth and make the volume to 4 litres by adding water. Allow it to stand for some days and filter through cotton wool or blotting paper into bottles.

(ii) Red Ink

Gum arabic	=25 gm.
Carbolic acid (phenol)	=5 gm.
Eosine	=80 gm.
Water	=4.6 litres

Dissolve the eosine in 3 litres of boiling water. Dissolve the gum in 1.5 litres of water and allow the solution to stand overnight.

Mix the two solutions and stir vigorously for some time. Filter red ink into bottles.

12. Ink-remover

A solution of chlorine bleaches the ink. Therefore for preparing ink-remover pass chlorine gas through water till it starts smelling the gas. Chlorine gas can be prepared by dropping conc. HCl on solid potassium permanganate.

13. Boot-Polish

Fig. 38.

Carnauba wax	=60 gm.
Montan wax	=40 „
Ceresine wax	=70 „
Paraffin wax	=40 „
Turpentine oil	=1125 ml.
Colour (Nigrosine for black-polish)	=30 gm.

Melt the waxes together and then add to them slowly the turpentine oil in which has been dissolved the nigrosine (colour). Stir the whole mass till uniform and fill in tin boxes.

14. Metal-polish

Water	=675 ml.
Triethanolamine	2 gm.
Oleic acid	=4 gm.
Naphtha	=360 ml.
Clay or chalk	=32 gms.
Strong ammonia	=6 ml.



Fig. 39.

Dissolve the triethanolamine in water and then add while stirring in the chalk. In a separate container mix naphtha and oleic acid to uniform solution and add first mixture to it. Stir when a smooth emulsion is formed, add ammonia and store in bottles.

15. Matches

Two types of matches are in market (i) Safety matches and (ii) Strike-anywhere safety matches. The former one is more common and so only their method of making is given here.

The whole process of making can be divided into two steps.

- (i) Making of the combustible part, i.e., the sticks.
- (ii) Striking surface, which starts combustion.

(i) Match sticks

Potassium chlorate	=112 gm.
Antimony sulphide	=25 gm.
Sulphur	=25 gm.
Sand	=20 gm.
Glue	=25 gm.

Make a paste of the above materials. Take some soft wood and cut splinters of suitable size out of it. Soak these splinters in a dilute solution of alum and dry. This process avoids smouldering of the sticks after being extinguished. Dip the tips of the dried sticks in above paste and let them dry.

(If you want to protect the sticks from moisture, give them another dip in wax.)

(ii) Striking surface

Red phosphorus = 6 gm.

Powdered glass = 10 gm.

Glue = 15 gm.

Make a fine paste of the materials and apply them with the help of a small brush on one side of a box or some card-board piece.



← Pot. chlorate + Antimony
Sulphide + Sulphur
+ Sand + Glue

Red Phosphorous
+ Glass Powder + Glue

Striking surface

← Wooden splinter soaked
in alum solution

16. Coloured matches

To produce the different colours in the flame, you can add a little amount of salt to the paste made for match sticks.

Copper or Barium salt — Green flame

Strontium salt — Crimson red

17. How to make Rayon

Copper sulphate	=5 gm.
Ammonium hydroxide	=28% solution
Sulphuric acid	=5% „

Dissolve about 5 gm. of copper sulphate (नीला थोया) in 100 ml. of warm water. Add 28% ammonia solution to it drop-wise and with constant stirring, till all the copper precipitates as copper hydroxide. Decant the supernatant solution and wash the precipitates several times with water. Dissolve the washed ppts. in minimum quantity of ammonia. The resulting solution has the unusual property of being able to dissolve paper, cotton and other forms of cellulose. Dissolve bits of paper (filter) in it until the solution becomes syrup. Fill a medicine dropper with the syrup solution and squeeze it under the surface of a 5% solution of sulphuric acid. The solution hardens as it



Fig. 40.

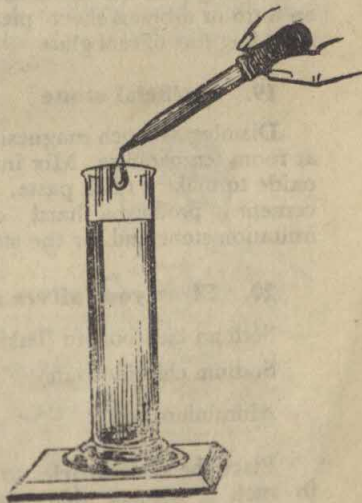


Fig. 41.

leaves the dropper, forming a little worm of regenerated cellulose.

18. How to make glass

Glass, which is the constituting material of most of the articles in daily use, is nothing, but a mixture of an alkali silicate with the silicate of base, *i.e.*, sand, sodium carbonate and lime. However, there are various types of glasses, but by following the procedure described below you can make a sample of glass yourself in the laboratory.

White sand = 3 gm.

Sodium carbonate (dry) = 3 gm.

Yellow lead oxide = 3 gm.

Mix the three things and put the mixture in a crucible and heat strongly until it melts into a fluid mass. Pour the contents on a tin or asbestos sheet piece. Upon cooling, you will find sparkling bits of real glass.

19. Artificial stone

Dissolve as much magnesium chloride as possible in water at room temperature. Mix into this solution enough magnesium oxide to make a thick paste. The paste will react rapidly like cement to produce a hard durable material used widely for imitation stone and for the stone-like flooring of office buildings.

20. Clean your silver articles

Sodium bicarbonate (baking soda)

Sodium chloride (salt)

Aluminium pan.

Place the silver articles to be cleaned in an aluminium pan in such a manner that each article touches the pan. Cover these with a hot solution containing one teaspoonful of sodium

bicarbonate and another of salt (NaCl) per 250 ml. of water.

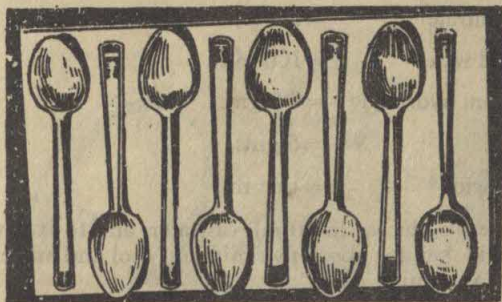


Fig. 42.

After a few minutes, remove the articles, rinse and polish with a soft cloth.

Touching the aluminium^a and surrounded by the electrolyte, the silver article forms one plate of an electric cell. By action of this cell, the tarnish of silver sulphide is dissolved, the sulphur is separated and the silver is redeposited.

21. Silver your mirrors

MIRROR SILVERING



Fig. 43.

Ammonium hydroxide = 28% solution

Silver nitrate = 1.0 gm.

Distilled water = 100 ml.

Potassium hydroxide = 0.5 gm.

Glucose = 5 gms.

Nitric acid = one ml.

Dissolve the glucose in 50 ml. of water, add to it few drops of nitric acid. boil for about five minutes, cool and store in some container (as solution A).

Dissolve the silver nitrate in 50 ml. of water and add ammonia solution dropwise till a precipitate first formed gets dissolved. To the clear solution add potassium hydroxide solution, when a precipitate again forms. Dissolve the ppts. by adding ammonia dropwise. *Do not add excess of ammonia. Excess of ammonia prevents the deposition of silver.* Add a few drops of silver nitrate solution to the clear solution till a permanent dark colour persists. Store it in a dark bottle as solution B.

Now clean the glass sheet to be mirrored with washing soda, alcohol and finally with nitric acid. *Do not touch the surface of the article after cleaning.* Put the sheet in a tray and pour a mixture of solution A and B (in 1 : 4 ratio by volume) on its centre so that it spreads to all directions upto the edges of sheet. After 15 minutes drain off the spent up solution and give a second coat in the same manner. After silvering, the glass is rinsed with cold water and allowed to dry. After complete drying, give a protective varnish or paint coating with the help of a soft brush.

Note. Use the solution B, on the same day.

22. Pharaoh's Serpents

Potassium dichromate = 10 gms.

Potassium nitrate = 5 gms.

Sugar = 5 gms.

Reduce each item to a fine powder by means of a pestle and mortar, washing and drying the mortar between the operations.

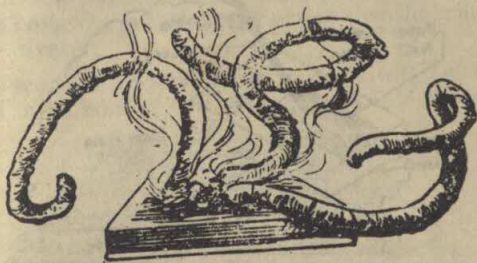


Fig. 44.

Mix the various powders thoroughly, using a pointed stick of wood. Make some tiny paper cones, fill them with the mixed powder and close the tips of the cones. Place a cone on a metal tray and light it at the top. The little paper 'egg' will emit a long trail of serpent like material.

23. Sparkling Torches

Powdered sulphur = 5 gms.

Potassium nitrate = 30 gms.

Aluminium powder = 5 gms.

Iron filings = 5 gms.

Fine wheat flour = 5 gms.

Make a paste of all the above ingredients. Stick the paste on pieces of wires (only on the half of the wire). Stick some additional aluminium and iron filings, while the wires are still wet and let them dry perfectly. On igniting, they will give out beautiful silvery and golden sparks.

24. Electric Writing

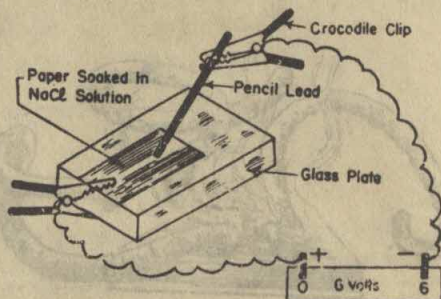


Fig. 45.

Sodium chloride = 1.5 gms.

Phenolphthalein solution.

6 volt battery

Dissolve about 1.5 gms. of sodium chloride (common salt) in 2 ml. of water. Add 3 drops of phenolphthalein solution to it and drop this mixture on a piece of white blotting paper or filter paper until it is just wetted. Put the wet paper on a small piece of glass and attach a crocodile clip on both paper and glass as shown in Fig. 45. Connect it to the anode (+ve) of a 6 volt battery. Attach a pencil lead with the cathode of the battery and write lightly with its help on the wet paper. The writing will appear *red* owing to the formation of alkali at the cathode.

Note : Do not go on this experiment too long, as Cl_2 gas is evolved at the anode which is poisonous.

If instead of phenolphthalein, blue litmus solution is used in above experiment and pencil lead is attached to the anode (+ve), then a white writing on blue background will be there.

25. Chemical Garden

A chemical garden affords a beautiful experiment which no home or school chemist should miss. Take a small fish bowl or jar and sprinkle a layer of coarse sand about a quarter of inch deep on the bottom. Fill the remainder jar with water

glass (sodium silicate) diluted with an equal amount of water. Drop in it few crystals of each—copper sulphate ; cobalt chloride ; ferrous sulphate ; zinc sulphate ; nickle sulphate and manganese chloride, in such a manner so that the colour distributes attractively.

Within seconds, some of these crystals will be sending up shoots and in an hour or two the garden should be completely



Fig. 46.

grown—a forest of intricate and varicoloured growth that suggests an underwater fairyland. After a day, the sodium silicate solution should be carefully siphoned off and replaced with fresh water. As the "plants" are metallic silicates, they will not dissolve. They will last until they are broken by jarring.

APPENDIX II

LABORATORY ACCIDENTS AND FIRST AID

In case of accident, bring it to the notice of teacher present, at once.

Each chemical laboratory should be provided with a first aid box or cupboard containing the following articles clearly labelled.

Bandages (several sizes), gauze, cotton wool, adhesive plaster and a sling.

Delicate forceps, needles, thread, scissors and safety pins.

Fine glass dropper.

Two eye glasses.

Vaseline, Castor oil, Olive oil, Boric acid powder, Sodium bicarbonate powder, Chloramine-T powder, Tincture of Iodine, Burnol (Acriflavine jelly), Tannic acid jelly.

Bottles containing

1% acetic acid,

1% boric acid,

Saturated sodium bicarbonate solution.

1% sod. bicarbonate solution.

Rectified spirit.

Glycerine, Light petroleum (b.pt. 80—100°C).

A disinfectant, e.g., Dettol and a fire-proof blanket.

Burns

Burns caused by dry heat (e.g., by flames, hot objects etc.) for slight burns in which the skin is not broken, apply tannic acid jelly or burnol. For larger burns, apply one percent sod. bicarbonate solution without delay, and call for medical aid at once.

LABORATORY ACCIDENTS AND FIRST AID

Burn caused by Acids. Wash immediately and thoroughly with large amount of water, then with saturated sodium bicarbonate solution, and finally with water. For a serious acid burn, follow this by applying a dettol, drying the skin and covering with burnol.

Burn caused by Alkalis : Wash immediately with liberal amount of water, then with 1% acetic acid, and finally with water. For serious burn, follow this treatment by applying a disinfectant, drying the skin and covering with burnol.

Burns caused by bromine : Wash the affected part immediately with liberal amount of light petrolcum (b.pt. 80—100°C), and then rub glycerine well into the skin.

Burn caused by sodium metal : Remove the Na—piece, if any with a forcep. Wash thoroughly with water, then with 1% HAc, and finally cover with gauze soaked in olive oil or burnol.

Burn caused by organic substances : Wash freely with rectified spirit then with soap and warm water.

Cuts

If the cut is only a minor one, allow to bleed for a few seconds ; see that no glass remains inside ; apply a disinfectant and bandage.

For serious cuts, send for a doctor at once ; meanwhile wash with a disinfectant and try to stop bleeding by applying pressure.

Fires

Burning Cloth : Prevent the person from running and fanning the flames. Make the victim to lie down on the floor and wrap the fire-proof blanket around the ignited clothes until the fire is extinguished.

Burning reagents. Turn out all the gas burners and switch off all the nearby electric hot plates. Remove everything which may ignite. A small fire may be extinguished by covering the opening of the vessel with a clean damp cloth or duster ; the fire usually dies out due to lack of fresh air. For larger fires, dry sand and commercial fire extinguishers can be applied.

Sand once used should not be used again. For burning oil, never use water.

Poisons

Spit out at once and wash repeatedly with water. Call a doctor immediately. In the meantime, give an antidote according to the nature of the poison.

(i) *Acids* : Dilute by drinking much water followed by lime water or milk of magnesia. Milk may then be given.

(ii) *Caustic alkalis* : Dilute by drinking much water, followed by vinegar, lemon or orange juice. Milk may then be given.

(iii) *Salts of heavy metals* : Give milk or white of an egg.

(iv) *Arsenic or mercury compounds* : Give an emetic immediately, e.g., one teaspoonful of mustard, or one tablespoonful of salt in a glass of warm water.

Gas

Remove the victim to the open air, and loosen clothing at neck. To counteract chlorine or bromine fumes if inhaled in only small amounts, inhale ammonia vapour or gargle with sodium bicarbonate solution.

If breathing has stopped, apply artificial respiration.

Eye Accidents

In all cases the patient should see a doctor. In the meantime, first aid should be given.

For acids : If the acid is dilute, wash the eye repeatedly with 1% sod. bicarbonate solution in the eye cup. If the acid is concentrated, first wash the eye with a large amount of water and then continue with the bicarbonate solution.

Caustic alkali : Proceed as for acid in the eye, but use 1% boric acid solution instead of bicarbonate solution.

Glass in the eye : Remove loose glass very gently with forceps or by washing with water in the eye cup. Call for a doctor immediately.

APPENDIX III ATOMIC WEIGHTS

<i>Name of element</i>	<i>Symbol</i>	<i>At. wt.</i>	<i>Name of element</i>	<i>Symbol</i>	<i>At. wt.</i>
Aluminium	Al	26.98	Manganese	Mn	54.94
Antimony	Sb	121.76	Mercury	Hg	200.61
Arsenic	As	74.91	Molybdenum	Mo	95.95
Barium	Ba	137.36	Nickel	Ni	58.69
Beryllium	Be	9.03	Nitrogen	N	14.008
Bismuth	Bi	209.00	Oxygen	O	16.000
Boron	B	10.82	Palladium	Pd	106.7
Bromine	Br	79.92	Phosphorus	P	30.98
Cadmium	Cd	112.41	Platinum	Pt	195.23
Calcium	Ca	40.08	Potassium	K	39.10
Carbon	C	12.011	Selenium	Se	78.96
Cerium	Ce	140.13	Silicon	Si	28.09
Chlorine	Cl	35.46	Silver	Ag	107.88
Chromium	Cr	52.01	Sodium	Na	22.99
Cobalt	Co	58.94	Strontium	Sr	87.63
Copper	Cu	36.54	Sulphur	S	32.066
Fluorine	F	19.00	Tellurium	Te	127.61
Germanium	Ge	72.60	Thorium	Th	232.05
Gold	Au	197.0	Tin	Sn	118.70
Hydrogen	H	1.008	Titanium	Ti	47.90
Iodine	I	126.91	Tungsten	W	183.92
Iron	Fe	55.85	Uranium	U	238.07
Lead	Pb	207.21	Vanadium	V	50.95
Lithium	Li	6.940	Zinc	Zn	65.38
Magnesium	Mg	24.32	Zirconium	Zr	91.22

APPENDIX IV

SOME MORE COMMON NAMES OF DIFFERENT CHEMICALS

Name	Chemical Name	Formula
Blue Vitriol	Copper sulphate	$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
Green Vitriol	Ferrous sulphate	$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$
Epsom	Magnesium sulphate	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$
Plaster of Paris	Calcium sulphate (anhydrous)	$\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$
Gypsum	Calcium sulphate	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$
Washing soda	Sodium carbonate	$\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$
Common salt or Rock salt	Sodium chloride	NaCl
Nitre or Salt petre	Potassium nitrate	KNO_3
Baking soda	Sod. bicarbonate	NaHCO_3
Chalk	Calcium carbonate	CaCO_3
Caustic lunar	Silver nitrate	AgNO_3
Quick lime	Calcium oxide	CaO
Slaked lime or Milk of lime	Calcium hydroxide	Ca(OH)_2
Alum	Pot. Aluminium sulphate	$\text{K}_2\text{SO}_4 \cdot \text{Al}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$
Bleaching powder	Calcium oxychloride	CaOCl_2
Carbolic Acid	Phenol	$\text{C}_6\text{H}_5\text{OH}$
Talc	Magnesium silicate	MgSiO_3
Water glass	Sodium silicate	Na_2SiO_3

APPENDIX V

DATA ON THE STRENGTH OF AQUEOUS SOLUTIONS OF THE COMMON ACIDS AND OF AQUEOUS AMMONIA

Reagent	Approximate			Vol. required to make 1 lt. of approx. N solution (ml.)
	% by weight	Sp gravity	Normality	
Hydrochloric acid	35	1.18	11.3	89
Nitric acid	70	1.42	16.0	63
Sulphuric acid	96	1.84	36.0	28
Phosphoric acid	85	1.69	41.1	23
Acetic acid	99.5	1.05	17.4	58
Aqueous ammonia	27	0.90	14.3	71

SATURATED SOLUTION OF SOME REAGENTS AT 20°

Reagent	Formula	Sp. gravity	Molarity	Quantities required for 1 lt. of saturated solution	
				gms. of Reagent	ml. of Water
Amm. chloride	NH_4Cl	1.075	5.44	291	784
Amm. nitrate	NH_4NO_3	1.312	10.80	863	449
Amm. sulphate	$(\text{NH}_4)_2\text{SO}_4$	1.243	4.06	535	708
Pot. chloride	KCl	1.174	4.00	298	876
Pot. dichromate	$\text{K}_2\text{Cr}_2\text{O}_7$	1.077	0.39	115	962
Pot. hydroxide	KOH	1.540	14.50	813	727
Sod. carbonate	Na_2CO_3	1.178	1.97	209	869
Sod. chloride	NaCl	1.197	5.40	316	881
Sod. hydroxide	NaOH	1.539	20.07	803	736
Barium chloride	$\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$	1.290	1.63	398	892

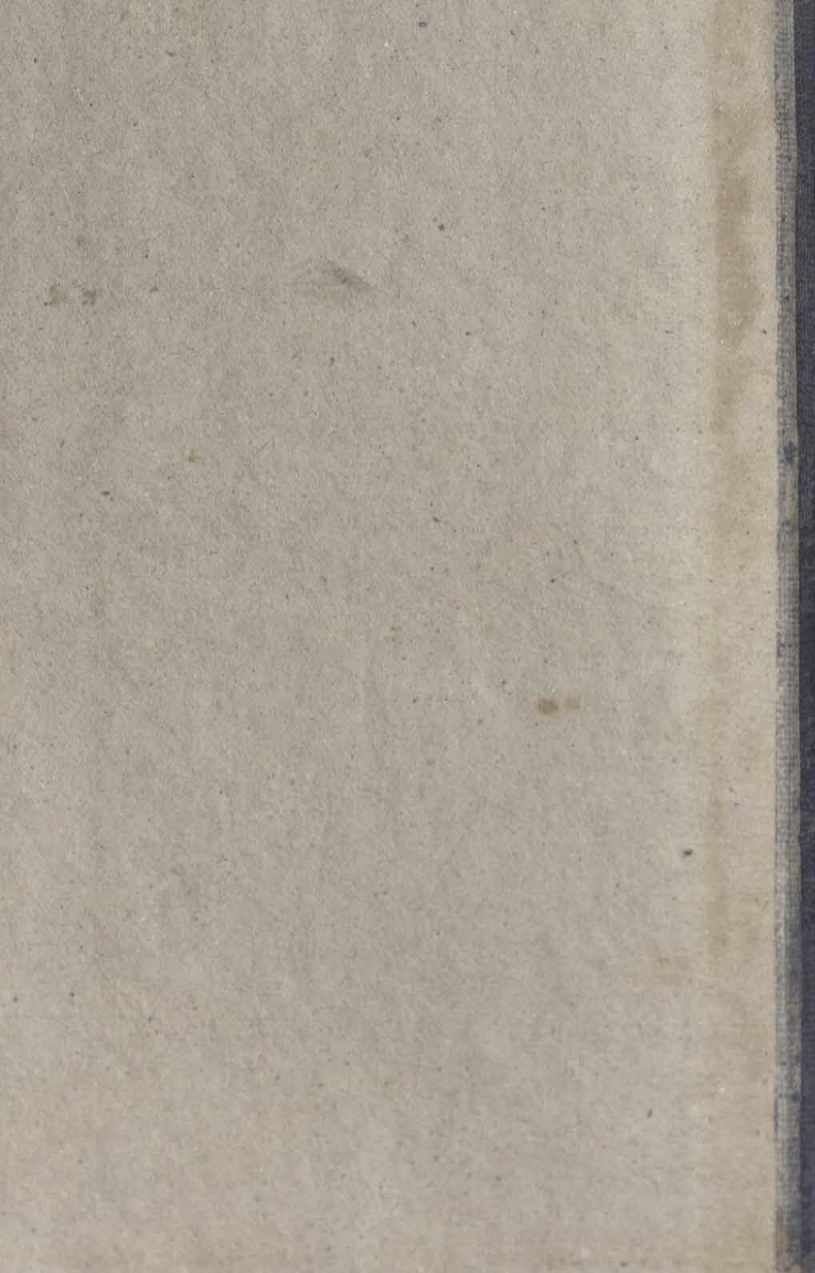
APPENDIX VI

REAGENTS

<i>Reagent</i>	<i>Mol. wt.</i>	<i>Preparation</i>	<i>Approx. strength</i>
Ammonium acetate	77	Dissolve 231 gms. of the salt in one litre of water.	3N
Ammonium carbonate	96	Dissolve 160 gms. of the salt in some water. Add to it 140 ml. of conc. ammonia and make the total volume 1 litre by diluting with water.	4N
Ammonium chloride	53.5	Dissolve 270 gms. of the salt in one litre of water.	5N
Ammonium oxalate	142	Dissolve 35 gms. of the salt in 1 litre of water.	0.5N
Ammonium thiocyanate	76	Dissolve 38 gms. of the salt in one litre of water.	0.5N
Barium chloride	244	Dissolve 61 gms. of the salt in one litre of water.	0.5N
Bromine water	160	Prepare a saturated solution by shaking 11 ml. of liquid bromine with one litre of water.	0.5N
Calcium chloride	219	Dissolve 55 gms. of the hydrated salt in one litre of water.	0.5N

<i>Reagent</i>	<i>Mol. wt.</i>	<i>Preparation</i>	<i>Approx. strength</i>
Chlorine water	71	Pass chlorine gas through water, until it begins to smell of the gas.	
Cobalt nitrate		Dissolve 44 gms. of the salt in 1 litre of water.	0.3N
Copper sulphate	249.5	Dissolve 125 gms. of the salt in one litre of water containing 3 ml. of H_2SO_4 .	0.5N
Dimethylglyoxime		Dissolve 1 gm. of the substance in 100 ml. of alcohol or rectified spirit.	
Ferric chloride	270	Dissolve 135 gms. of the salt in one litre of water containing 20 ml. of conc. HCl.	0.5N
Iodine solution	254	Dissolve 12.7 gms. of Iodine in a solution of 20 gms. of KI in 30 ml. of water and dilute the content to one litre.	0.1N
Lead acetate	379	Dissolve 95 gms. of the salt in about 200 ml. water by warming and adding acetic acid till a clear solution is obtained. Dilute the solution to one litre by water.	0.5N

<i>Reagent</i>	<i>Mol. wt.</i>	<i>Preparation</i>	<i>Approx. strength</i>
Mercuric chloride	272	Dissolve 27 gms. of the salt in one litre of water.	0.2N
Potassium chromate	194	Dissolve 49 gms. of the salt in 1 litre of water.	0.5N
Potassium Ferrocyanide		Dissolve 53 gms. of the salt in 1 litre of water.	0.5N
Potassium Ferricyanide		Dissolve 55 gms. of the salt in 1 litre of water.	0.5N
Potassium Iodide	166	Dissolve 83 gms. of the salt in 1 litre of water.	0.5N
Potassium permanganate		Dissolve 3.2 gms. of the salt in 1 litre of water.	0.1N
Potassium thiocyanate	97	Dissolve 49 gms. of the salt in 1 litre of water.	0.5N
Silver nitrate	170	Dissolve 17 gms. of the salt in one litre of water and store the solution in brown bottles.	0.1N
Sodium nitroprusside		Dissolve a crystal in 5 ml. of water.	
Stannous chloride		Dissolve 56 gms. of the salt in 100 ml. of conc. HCl and dilute to one litre by water. Keep a few pieces of tin in the solution to prevent oxidation.	0.5N





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